APPENDIX C
ECONOMICS

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APPENDIX C
ECONOMICS

1. INTRODUCTION

The level of waterborne commerce on the Columbia River has continued to show steady growth, along with an increase in the size of commercial vessels using the navigation channel. Average vessel size has increased due to the efficiencies gained by shippers using larger vessels to transport both bulk and containerized commodities. With the increased use of panamax vessels for transport of bulk commodities such as wheat and corn, limitations posed by the existing channel dimensions now occur with greater frequency. Also, container vessels are showing a rapid increase in vessel size, and competition exerts pressure to fully load these vessels. Ships with design drafts approaching or greater than the 40-foot depth constraint can not fully utilize their capacity. The approach utilized in this analysis to identify potential savings from modification of the existing channel involved a number of elements.

1.1. Purpose and Scope

The purpose of this study is to assess the economic viability of various improvements to the existing 40-foot navigation channel of the lower Columbia River. Potential economic benefits would be in the form of lower operating costs of waterborne transport and reduced vessel delay costs.

1.2. Study Area Location and Description

The Columbia River is the largest river on the west coast of North America and drains over 250,000 square miles in the northwestern United States and southwestern Canada. It rises in British Columbia, enters the United States in northeastern Washington, and empties into the Pacific Ocean 645 miles north of San Francisco Bay and 160 miles south of the Strait of Juan de Fuca. The total length of the river is 1,210 miles. The Columbia forms the boundary between the States of Washington and Oregon and the lower 106.5 miles of river, which is accessible to oceangoing freighters, lies west (seaward) of the Cascade mountain range. This portion of the river comprises the study area, along with the lower 11.6 miles of Willamette River, a major tributary that enters the Columbia River at Portland, Oregon.

1.3. Authorized Project

The Columbia River 40-foot navigation channel extends inland from the Pacific Ocean for 106.5 river miles to Vancouver, Washington, and up the Willamette River from its confluence with the Columbia River to the Broadway Bridge at Portland, Oregon. The channel provides a deep-draft waterway that allows oceangoing vessels access to inland port facilities. The Columbia River navigation channel has been a federally authorized project since 1877. In the 1930s, it was developed to dimensions of 35 feet in depth and 500 feet in width. A 40-fot by 600-foot channel was authorized in the Rivers and Harbors Act of 1962, and was essentially completed by 1972. At present, the depth of the authorized navigation channel is 40 feet.

The river entrance extends two miles seaward and three miles landward from the outer ends of the Columbia River jetties at the Pacific Ocean. In 1957, the entrance was deepened to 48 feet and maintained at that depth until 1984, when it was deepened to 55 feet to provide improved navigability of the bar and to make the entrance depth more compatible with the 40-foot river channel. The navigation channel and entrance are maintained on a continuing basis. From 1985 through 1989, an average 7.3 million cubic yards of material was dredged from the navigation channel each year. Over the same period, an average 5.78 million cubic yards were removed annually from the entrance.

Pacific Ocean tides are of diurnal inequality; two high tides and two low tides occur every 24.8 hours. These ocean tides affect river stages as far inland as Bonneville Dam at Columbia River mile (CRM) 145 and consequently, impact maritime activity on the waterway. The mean diurnal tide range at the river entrance is 7.5 feet, and average tide differential is 4 feet. The average tide range at Portland-Vancouver is 2.5 feet.

1.4. Problems and Needs

The level of waterborne commerce on the Columbia River has expanded over time, coupled with an increase in the size of commercial transport vessels using the navigation channel. Average vessel size has increased due to efficiencies gained by use of larger vessels to transport bulk commodities, which comprise the majority of export tonnage shipped via the Columbia channel. With the increased use of panamax-class vessels for transport of bulk commodities such as wheat and corn, limitations posed by channel dimensions are occurring with greater frequency. Ships with design drafts approaching the 40-foot constraint or greater may not be able to fully utilize their design drafts because of channel depth limitations, forcing those vessels to operate at less than optimal efficiency.

1.5. Structure of Analysis

The approach utilized in this analysis to identify potential savings from modification of the existing channel involves a number of elements. One essential element is the projected volume of commodities expected to move to and from ports on the lower Columbia River. Another critical element is the projected fleet of vessels expected to call on the lower Columbia River. The projected volume of commodities is matched to the projected fleet in order to evaluate transportation costs under various conditions. Alternative plans can then be compared to determine the benefits associated with improving the navigation channel.

The major benefit categories associated with the channel improvement are transportation savings and delay savings. Transportation savings result from economies of scale that may occur when deeper draft vessels carry more tonnage per vessel. These savings can accrue up to the point where vessels are constrained by channel depth. In a deeper channel, greater savings can accrue. Transportation benefits measure the magnitude of economies of scale savings between the without-project condition and with-project condition. Vessel delay costs measure the costs of the time delay and associated operating costs, which deep-draft vessels may incur when approaching the maximum draft accommodated by the channel depth. Vessel delay benefits reflect the savings in vessel operating costs between the without- and the with-project conditions.

Section 5 of this report describes the basic inputs into the calculation of the benefits attributable to various alternatives and the waterborne commerce, past movements and projected future movements on the Columbia. Section 6 describes historical and projected fleet composition. Section 7 describes the components of the commodity transportation cost calculations, including vessel operating costs and vessel operating practices.

2. DEFINITION OF WITHOUT-PROJECT CONDITION

The without-project condition is defined as the condition and practice expected to exist in the project area during the study period in the absence of implementation of any other federal project related to the navigation channel. Specifically, the without-project condition consists of the existing authorized 40-foot deep by 600-foot wide navigation channel. The without-project condition assumes that there will be no significant structural modifications to the channel. The existing channel serves the deep-water ports of Kalama, Longview, Portland, and Vancouver, as well as numerous smaller ports in the area. The Columbia River entrance (bar) was authorized to a depth of 55 feet in 1983 and completed in 1984.

It is important to recognize that actual practices are the basis of the definition of the existing without-project condition. This is important because although the existing authorized channel is maintained at a minimum uniform depth of 40 feet, it is actually deeper than 40 feet in areas from the mouth to Portland. Consequently, the existing traffic on the river has something in excess of 40 feet of water depth availability most of the time, and vessel traffic frequently takes advantage of that extra water depth availability (water available to a vessel to transit the river channel). It is estimated that the existing channel provides approximately 42 feet of water depth availability most of the time. This allows vessels to transit the river at actual drafts of 40 feet, using the additional depth available in the channel for underkeel clearance. This practice is expected to continue in all alternatives.

3. DEFINITION OF WITH-PROJECT CONDITION ALTERNATIVES

The with-project alternatives to be studied are channel improvements that provide 41-, 42- and 43 feet of water depth availability. The channel improvements were not necessarily uniform channel depths, but would provide water depth availability for vessels to transit the channel. A non-structural alternative and a regional port alternative are also addressed below. As with the base condition, it is expected that vessels will continue to have additional depth availability due to tides and natural channel depths. In a 43-foot channel vessels will, as in the base condition, be able to use this additional depth for underkeel clearance.

3.1. Non-Structural Measures

The non-structural alternative consists of upgrading the existing river stage forecasting system (called *Loadmax*) to enable ships to determine navigable channel depths based upon projected future and real-time tide and river stage information. This allows vessels to safely depart at depths greater than the authorized channel depth. An analysis of navigation practices on the Columbia River found that available water depths were not fully utilized by ships, even by the deepest 90 percent of the fleet. Most container lines target a 36-foot draft and only schedule enough outbound cargo to reach that draft. Because cargo is not scheduled at the dock, container ships with design drafts of 38 to 41 feet can not take advantage of the water depths available at their scheduled sailing time. Bulk carriers make better use of available water depths because their sailing draft is selected just hours prior to departure. The bulk carriers can also delay departure to wait for maximum water depths.

There are several limitations to the existing river stage forecasting system that prevent shippers from making maximum use of the available water depths in the Columbia River.

- Concern about the accuracy of the river stage forecast.
- The river stage forecast is presented for only six locations, and does not present a clear picture of expected river conditions.
- Since navigation channel bed elevations are not included in the forecast, the total water depth available is not available.
- The six-day forecast does not allow enough time for container lines to schedule cargo to take full advantage of expected water depths.

It would be possible to improve the river stage forecasting system (*Loadmax*) to overcome the above limitations. New technology and better use of available data would improve the reliability and usefulness of the forecasts. Updated one- and two-dimensional hydraulic models could be used to improve the accuracy of the stage forecast. These models would also provide a continuous water surface profile along the entire channel, rather than just at the current six locations. The water surface elevations forecast for the six gage locations could be regularly compared to the observed elevations to monitor and maintain the accuracy of the forecasts. The controlling depths from Corps' navigation surveys could be combined with the water surface profiles to provide a forecast of total water depth available along the entire navigation channel.

The Columbia River hydropower system reservoir operation forecasts could be used to provide expected river discharges for up to a month in advance, which could then be used to provide advanced river stage forecasts. Although there would be more uncertainty with such long-range forecasts, it could allow container lines to schedule cargo to take advantage of potential higher river stages.

The potential benefits of an improved river stage forecast system are difficult to judge with precision. An evaluation was conducted to measure the increase in departure draft that could have been obtained on actual transits in 1991 to 1993. During this period, the potential vessel draft benefits from an improved stage forecasting system for the deepest 240 bulk carriers (target draft 40 feet) and 67 deepest container ships (target draft 36 feet) are shown in Table 1.

The maximum potential drafts are based on the estimates of the minimum water depth available during transits studied in the navigation analysis (see Appendix A, *Engineering*). The potential drafts could have been accomplished without changing the ship's departure time or exceeding the minimum underkeel clearance requirements.

Table 1. Potential Vessel Draft Benefits

BULK CARRIERS			CONTAINER SHIPS		
Maximum Potential Draft (feet)	**Number of Ships**	**Percent of Sample**	**Maximum Potential Draft (feet)**	**Number of Ships**	**Percent of Sample**
41	45	19	37	16	24
42	13	5	38	7	10
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Most of the bulk carriers with a potential to sail at 41- or 42-foot drafts (instead of 40 feet) were from the Port of Kalama (corn-carrying vessels). Additional draft increases may be available to container ships that could schedule departure times to take advantage of the water depth available. The potential for deeper drafts on container ships is supported by 1994 to 1995 data that shows about 30 percent of those ships sailed with drafts over the target draft of 36 feet, including nine percent that sailed with drafts over 38 feet.

It is estimated that an improved river stage forecast system could be implemented for about $500,000, and have an additional annual operational cost of about $100,000. The benefits of this alternative could be substantial, relative to the costs. It appears that 20 percent of the benefits of a 41-foot channel could be achieved through this measure, and, additionally, it appears that 5 percent of the benefits of a 42-foot channel could also be achieved through this measure. Additional benefits are possible, especially with bulk commodities, if some acceptable level of delay is added into the equation. This alternative is expected to increase net benefits when added to any deepening alternative, essentially, for example, allowing some vessels to act as though a 43-foot channel was one or two feet deeper. While the benefits of a 44-foot channel are outside the scope of this analysis, an examination of the incremental benefits for the 43-foot channel indicate that 20 percent of the benefits of a 44-foot channel are likely greater than the average annual cost of this non-structural alternative (approximately $140,000).

3.2. Regional Port Alternatives

As an alternative to improving the navigation channel, several alternatives have been formulated which involve development on new port facilities closer to the mouth of the Columbia with the intention of avoiding channel improvement costs. Two of these alternatives consist of construction of topping-off facilities that would be located at Astoria, close to the mouth of the river, or at Longview at CRM 66. Two other alternatives involve development of facilities at either Astoria or Longview to fully load any vessel that would depart the river at drafts greater than 40 feet.

3.2.1. Astoria, Single Stop Port

This alternative would involve constructing in Astoria all export facilities that would require over 40-foot drafts. New port facilities would be built for wheat, corn, and containers. These facilities would require hundreds of acres of land that is not currently available. An option would be to fill the existing Astoria port area and adjacent land in Young's Bay. The railroad and highway routes into Astoria would need to be upgraded to handle the large increase in freight traffic that would occur. By 2004, over 10 million tons of grain are expected to move on vessels of design draft 41 feet or greater. In terms of container traffic, it is expected that approximately 350,000 TEUs (twenty-foot equivalent units) will be loaded on vessels requiring over 40-foot drafts.

This alternative, relative to a channel improvement, will increase transportation costs. The costs of getting a ton of grain from the Portland area to the Astoria region by deep draft vessel is less than the cost of transporting grain via rail or barge. The costs of port development would probably exceed $400 million[1], which is more than double the current estimate of the channel improvement costs. There would also be negative environmental impacts due to the loss of shallow-water habitat in Young's Bay, the transportation improvements, and the urban development triggered by the new port facilities. This environmental impact is likely to be far more significant than the impact of the additional disposal sites created for the channel improvement alternatives. As the initial construction, transportation, and environmental costs of this alternative are much higher than those associated with channel improvement, it was not carried forward for further consideration.

3.2.2. Astoria, Topping-Off Port

A topping off facility, in order to be truly beneficial, would need to accommodate all three of the major export commodity groups. For wheat and corn, the concept of a topping off facility is easily identifiable and measurable. For containers, there are greater issues involved in determining if a topping-off facility would be feasible. Container traffic is schedule driven, and each stop made by a container vessel is planned and scheduled carefully. By adding a topping off facility, each vessel owner would need to determine if an additional vessel stop would be profitable. For the purposes of this analysis, it is assumed that all container vessel operators would be willing to make an additional stop on the Columbia River.

In the year 2004, a topping off facility would be expected to handle 360,000 short tons of wheat, 800,000 short tons of corn, and approximately 600,000 short tons of containers. By 2014, these numbers will increase to 800,000 short tons for wheat, 900,000 short tons for corn, and 1,000,000 short tons of containers.

The costs of transporting this traffic from the Portland or Kalama area to Astoria are much higher by rail or barge than by deep draft vessel[2]. For bulk grain vessels, the cost of

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[1] Estimated from the Port of Portland's *West Hayden Island Development Program Final Report*, which estimated costs for new grain and container facilities.

[2] It is assumed that this tonnage would not be transported to Portland for rehandling, but would be transported directly to the point of export.

transporting grain from Portland to Astoria ranges from $0.085 to $0.10 per short ton. The cheapest alternative method of transporting grain to Astoria is by barge, which would cost approximately $1.00 per ton. The majority of corn exports are not expected to be transported by barge, making rail the least cost alternative method of transportation. Using rail would increase costs to approximately $9.50 per ton. Currently, corn exports arrive at Kalama by rail.

Deep draft vessel transportation costs for containers average $0.50 to $1.00 per short ton for transit from Portland to the mouth of the Columbia. Currently, approximately 60 percent of container exports arrive at the Port of Portland via truck. Moving a container by truck from Portland to Astoria would cost approximately $260, or about $22 per ton. Ten percent of the container traffic arriving in Portland is transported by barge, and allowing those barges to continue on to Astoria would increase costs by approximately $5.00 per ton.

Infrastructure costs for a topping-off facility would also be significant. Topping-off facilities for wheat, corn, and containers would likely require an upgrade of the rail line from Portland to Astoria. Upgrading the railroad was estimated to cost $50,000,000 in the Corp's *Columbia River Coal Export Channel* study (1987). A 1984 study by Northwest Economic Associates for the Corps estimated costs for a corn facility at $28 million, assuming annual capacity of 240,000 metric tons. For the purposes of a general comparison, it can be assumed that the costs of constructing a larger facility today would be much higher. Also, it can be assumed that wheat and container topping-off facilities would cost as least as much as the corn facility, if not more, resulting in a total infrastructure cost of at least $134,000,000. Adding in the present value of the additional transportation costs increases the total costs of this alternative to over $250,000,000, which is far in excess of cost estimates for the channel improvement alternatives. Therefore, this alternative was not carried forward for further consideration.

3.2.3. Longview, One Stop Port

This alternative would deepen the channel to Kalama and locate large wheat and container facilities in Longview. Several new wheat elevators and a container terminal the size of the Port of Portland's T-6 would have to be built in Longview. As with the Astoria one-stop alternative, this alternative would cost substantially more than the channel improvement alternatives, and was not being carried forward for further consideration.

3.2.4. Longview, Topping-Off Port

This alternative would deepen the channel to Kalama, using existing wheat elevators at Longview and Kalama, and building a new container terminal at Longview. No improvements would be needed for the railroad and highway systems.

The costs of this alternative include a small transportation cost increase as more wheat is shipped via barge or rail to Longview rather than Portland. A container topping-off facility, however, would represent a much higher cost. Assuming that container carriers would opt to make two vessel stops on the Columbia, there would need to be a substantial investment in a new container facility. Current industry estimates for costs on container terminals generally assume approximately $1,000,000 per acre. The Port of Portland has recently completed a study that included a cost estimate for a new container facility at Hayden Island. This facility, which includes a 190-acre container yard, is expected to cost over $325,000,000. Given these costs, it can be assumed, even if the container facility at Longview is only one-quarter this size and cost, that the costs of a topping-off facility, combined with the additional transportation costs of moving containers from the Portland area to Longview, would far exceed the costs of the channel improvement alternatives. Therefore, this alternative was not carried forward for further consideration.

4. EXISTING CONDITIONS

This section describes context in which the Columbia River exists in the Pacific Northwest. The following sections describe the regional economy, socio-economic profile, and the existing maritime facilities in the study area.

4.1. Regional Economy

The economy of the Pacific Northwest has historically been resource-based with relatively strong dependence on timber and agriculture as the primary resources. Although manufacturing, including the lumber and wood products and electronics sectors, has increased their share of goods exported from the region, the agriculture sector continues to maintain a sizable share of total exports from the region. Major sectors of the regional economy depend on an efficient transportation system to move commerce to and from the region in a cost-effective manner.

The lower Columbia River navigation channel is an important element of the regional transportation network. The channel has evolved in conjunction with the growth of specific industries and the development of other transportation modes, including the inland (shallow draft) waterway, the railway system, trucking, and air. While the 40-foot channel opens up the Portland metropolitan area to ocean shipping, the rail system and shallow draft waterway through the Columbia River gorge provide an efficient way to move goods to or from the east, and also to the valleys to the south and north of the metropolitan area. Development of the inland waterway tug and barge system has progressed 243 miles upstream of Portland on the Columbia River, and for 140 miles upstream on the Snake River to Lewiston, Idaho.

The Columbia inland waterway provides a transportation route through the Cascade Mountains and into the wheat-growing region of eastern Washington, eastern Oregon and Idaho. The Columbia River gorge through the Cascades also provides a means for the railroad to move cargo from east to west, or west to east. Grain is moved from the east through the gorge, off-loaded into elevators, and then exported to Pacific Rim and other destinations via the lower river channel. A portion of this grain comes from growing areas in the midwestern United States. Currently, the agricultural sector is the largest user of the navigation channel in terms of short tons of cargo moved.

4.2. Socio-Economic Profile

Seven counties border the lower Columbia River channel. These include Clatsop, Columbia and Multnomah on the Oregon shore, and Pacific, Wahkiakum, Cowlitz and Clark Counties in the state of Washington. The following information provides a demographic profile of those counties located immediately adjacent to the navigation channel.

Clatsop County is situated in the extreme northwest corner of Oregon. It is bounded on the north by the Columbia River and on the west by the Pacific Ocean. The county covers 873 square miles and experiences average annual rainfall of 69.59 inches with an annual mean temperature of 56 degrees. The largest city in Clatsop County is Astoria, with a 1990 population of 10,069, compared with the total county population of 33,301. Astoria is home of the Port of Astoria which is located at CRM 12. Principal industries are fishing, lumber, and agriculture.

Columbia County is located in northwest Oregon. It is bounded on the north by the Columbia River, on the west by Clatsop County, and on the east by Multnomah County. The county covers 687 square miles and had a population of 37,557 in 1990. The largest city in Columbia County is St. Helens, with a population of 7,535 and home of the Port of St. Helens. Principal industries are agriculture, lumber, and fishing. At present, the port (CRM 85) is not capable of handling deep draft vessels.

Multnomah County, with a 1990 population of 583,887, is bounded by the Columbia River on the north, Clackamas County on the south, Hood River County on the east and Washington County on the west. Portland, population 437,319, lies within Multnomah County and is the largest city in Oregon. In terms of land area, this county is the smallest in Oregon with 465 square miles. Annual precipitation is 37.39 inches in Multnomah County and the annual mean temperature is 52 degrees. Portland is home of the Port of Portland, located at CRM 105, which is the largest port in the region. Principal industries are manufacturing, transportation, wholesale and retail trade, and tourism.

Pacific County, located in the southwest corner of the State of Washington, is bounded on the west by the Pacific Ocean and on the south by the Columbia River. Average annual precipitation in this coastal county is 80.79 inches and the annual mean temperature is 50 degrees. Pacific County's population was 18,882 in 1990, and the county covers 908 square miles. The largest city in Pacific County is Raymond, with a population 2,901. Principal economic activities include wood products, seafood processing, and agriculture, and a small amount of tourism in Long Beach.

Wahkiakum County is located in the southwest part of the State of Washington. The county is bordered on the south by the Columbia River, on the west by Pacific County, and on the east by Cowlitz County. Wahkiakum County has an average annual precipitation of 111.32 inches, which is the highest in the State of Washington. The annual mean temperature for the county is 51 degrees. The county covers 261 square miles and had a 1990 population of 3,327. The largest city in the county is Cathlamet, with a population of 508. Principal economic activities are wood products and agriculture.

Cowlitz County, with a 1990 population of 82,119, is located in southwest Washington. It is bounded on the south by the Columbia River, on the west by Wahkiakum County, and on the east by Skamania County. Cowlitz County covers 1,143 square miles and is separated from Clark County to the southeast by the Lewis River. Average annual precipitation is 45.1 inches and the annual mean temperature is 51 degrees. The county is home to the deep draft ports of Kalama, located at CRM 75, and Longview, located at CRM 65. The City of Longview is the largest city in the county with a population of 31,499. The economic base of Cowlitz County is dependent on wood and paper products, metal production, and agricultural products.

Located in southwest Washington, Clark County is bounded on the south by the Columbia River, on the east by Skamania County and on the north by Cowlitz County. Average annual precipitation is 39 inches and the annual mean temperature is 53 degrees. Clark County has a 1990 population of 238,053. It covers 627 square miles and is home of the City of Vancouver, population 46,380. The Port of Vancouver, located at RM 105, is a major deep draft shipping port. Clark County is a major manufacturing and shipping center for wood products, metals and agricultural products. New commercial and residential development, along with a solid electronic manufacturing base, provides a positive outlook for job development in the area.

4.2.1. Population

Table 2 displays population figures for each county and the respective states by decade.

Table 2. Population, States of Oregon, Washington, and Selected Counties

	1950	1960	1970	1980	1990
Study Area	684,349	742,282	828,389	923,619	997,126
Oregon	1,521,341	1,768,687	2,091,533	2,633,149	2,842,321
Clatsop	30,776	27,380	28,473	32,489	33,301
Columbia	22,967	22,379	28,790	35,646	37,557
Multnomah	471,537	522,813	554,668	562,640	583,887
Total	525,280	572,572	611,931	630,775	654,745
Percent of Oregon	34.5	32.7	29.3	24.0	23.0
Washington	2,378,963	2,853,214	3,413,244	4,132,353	4,866,692
Pacific	16,558	14,674	15,796	17,237	18,882
Wahkiakum	3,835	3,426	3,592	3,832	3,327
Cowlitz	53,369	57,801	68,616	79,548	82,119
Clark	85,307	93,809	128,454	192,227	238,053
Total	159,069	169,710	216,458	292,844	342,381
Percent of Washington	6.7	5.95	6.3	7.1	7.0

Source: United States Census of Population, U.S. Department of Commerce, Bureau of the Census, 1950, 1960, 1970, 1980, and 1990.

4.2.2. Employment

The Portland Metropolitan Statistical Area (PMSA), which is made up of Multnomah, Washington, and Clackamas Counties, dominates the region in terms of population, employment and overall economic activity. Table 3 shows total projected nonagricultural wage and salary employment for two Oregon counties and the PMSA for 1992.

Table 3. Employment by Industry, Portland PMSA and Clatsop and Columbia Counties

Industry	Portland PMSA	Columbia County	Clatsop County
Total Wage and Salary	638,290	9,363	13,587
Manufacturing, Total	102,020	2,158	2,869
Lumber and Wood Products	6,338	787	515
Food and Kindred Products	8,514	NA	814
Paper and Allied Products	3,368	646	NA
Nonmanufacturing			
Construction and Mining	27,064	425	453
Trans., Comm. and Utilities	37,331	1,467	494
Trade	168,106	1,735	3,919
Finance/Ins./Real Estate	43,798	241	353
Services and Miscellaneous	161,911	1,443	2,942
Government	85,077	1,781	2,225

Note: These represent selected categories, so they may not add to totals.
Source: *Oregon Covered Employment and Payrolls*, State of Oregon, Employment Division, 1992.

Table 4 displays total nonagricultural wage and salary employment data for the four Washington Counties as of 1992.

Table 4. Employment by Industry, Pacific, Wahkiakum, Cowlitz, and Clark Counties

Industry	Pacific	Wahkiakum	Cowlitz	Clark
Total Wage and Salary	5,742	666	33,122	81,062
Manufacturing, Total	1,217	130	9,622	16,366
Lumber and Wood Products	*	*	2,729	1,425
Food and Kindred Products	*	*	80	1,276
Paper and Allied Products	*	*	3,928	3,121
Non-manufacturing				
Construction and Mining	185	16	1,989	6,110
Trans/Comm/Utilities	77	29	1,459	2,828
Trade	1,242	115	7,391	18,887
Finance/Ins/Real Estate	174	*	1,077	4,540
Services and Misc.	992	86	6,173	16,837
Government	1,430	197	4,804	14,527

*Note: County does not keep records or lacks specified industry.
Source: Annual Demographic Information, 1992 Washington State Employment Security Department.

Major employers are manufacturing, trade, services and government sectors. Table 5 displays the nonagricultural wage and salary employment for 1992 by sector for the seven counties and for the Oregon and Washington region.

Table 5. Employment by Industry

Industry	Oregon PMSH & 2 Counties	Washington 4 Counties	Regional
Total Wage and Salary	661,240	120,592	781,832
Manufacturing, Total	107,047	27,335	134,382
Lumber and Wood Prdcts	7,640	*	*
Food and Kindred Prdcts	9,328	*	*
Paper and Allied Prdcts	4,014	*	*
Nonmanufacturing			
Construction and Mining	27,942	8,300	36,242
Trans/Comm/Utilities	39,292	4,393	43,685
Trade	173,760	27,625	201,385
Finance/Ins/Real Estate	44,392	5,791	50,183
Services and Misc.	166,296	24,088	190,384
Government	89,083	20,958	110,041

Note: Some counties do not keep records or lack specified industries.
Source: Derived from the two preceding tables.

4.3. Maritime Facilities

The lower Columbia River ports provide a diversified array of services and facilities to support the maritime needs of the Pacific Northwest. The Port of Astoria, located in Clatsop County at CRM 12, concentrates on the export of logs. The Port of Portland exports wheat, soda ash, wood chips, barley, and lumber, and imports such items as alumina, limestone, salt (crude), autos, vans and parts, and cement. The Port of Vancouver exports wheat, copper concentrate, lumber, plywood, and building supplies, and imports such products as alumina, ore, fertilizers, plywood and veneer, and pipe. The Port of Longview exports logs, coke, potash, paper and newsprint, and wood chips, and imports alumina, salt (crude), coal tar pitch, bauxite, and chemicals. The Port of Kalama specializes in the export of corn, wheat, beet pulp pellets, sorghum, and soybeans, and imports toluene. The Port of St. Helens exports forest products. The Port of Woodland currently does not have marine facilities, but has access to the 40-foot channel.

Information on maritime facilities at the five deep draft ports on the Lower Columbia and Willamette Rivers is presented in the following paragraphs. Most of this information was extracted from *The Great Waterway 1994* by the Merchants Exchange and the Columbia Snake River Marketing Group.

4.3.1. Port of Portland

The Port of Portland is located approximately 105 miles upstream of the mouth of the Columbia River, at about river mile 9 (WRM) on the Willamette River. It is Oregon's largest port, as well as the largest port on the Columbia River system. For 1992, the port handled approximately 45 percent of Columbia River export volumes and almost 65 percent of Columbia River imports. It is a diversified port that includes marine terminals, marine services, the Portland International Airport, and two general aviation facilities.

The Port of Portland has numerous cargo docks. The Georgia Pacific Corporation's Linnton Wood Fiber terminal handles wood fiber shipments, and has a water depth of 35 feet. The Zidell Marine Front Street dock is used for barge loading and unloading and has a water depth of 20 feet. The Trumbull Asphalt wharf ships and receives asphalt, and has a water depth of 31 feet. The GATX Tank Storage Terminal Corporation, Portland Terminal dock, ships and receives liquid bulks, and has a water depth of 32 feet. The ARCO Petroleum Products Co. Linnton Terminal wharf handles petroleum products, and has a water depth of 35 feet. Mobil Oil Corporation, Linnton wharf, ships petroleum products and loads barges for bunkering vessels at berth. Time Oil Co. Linnton wharf ships petroleum products, and has a water depth of 35 feet. Pacific Northern Oil Corporation wharf ships petroleum products and fuels towboats, and has a water depth of 27 feet.

The ELF Atochem North America Inc. Chemical wharf ships and occasionally receives caustic soda, chlorine, sodium chlorate solutions and chlorine gas, and has a water depth of 30 feet. Shell Oil Co. Willbridge Plant pier receives and ships petroleum products and does occasional vessel bunkering, and has a water depth of 30 feet. Chevron USA Willbridge Plant pier receives and ships petroleum products, receives crude oil, does towboat bunkering, and has a water depth of 36 feet. Unocal Petroleum Products and Chemicals Division Portland Terminal pier receives and ships petroleum products, and loads barges for bunkering vessels at berth, and has a water depth of 37.5 feet on the lower side and 34 feet on the upper side.

The McCall Oil Corporation Terminal wharf receives and ships petroleum products, fuels towboats and loads barges for bunkering vessels at berth, and has a water depth of 37 feet at the face and 9 feet at the rear of face. The Western Transportation Co. Front Ave Distribution Center handles general cargo barge shipments and has a water depth of 35 feet. The Port of Portland's Terminal 2, Low Level Dock Berth 203, Roll-on/Roll-off Berth 204, Berth 205, and Berth 206 are used for handling conventional, containerized, roll-on/roll-off general and refrigerated cargo, including steel and lumber, and has a water depth of 40 feet.

Port of Portland Terminal 1, Berths 101, 102, 103, are used for general cargo barge and rail shipments, and have a water depth of 35 feet. Terminal 1, Barge Berth 104 is used for conventional, roll-on/roll-off general cargo by barge, and as a lay berth, with a water depth of 35 feet. Lonestar Northwest Inc. Front St. Dock receives sand and gravel by barge, and has a water depth of 35 feet. James River Corp. Lake Oswego Chip Reload ships wood chips by barge, and has a water depth of 16 feet. Ross Island Sand and Gravel Co. Hardtack Island Mooring receives and ships sand and gravel, and has a water depth of 12 feet.

The Lonestar Cement Northwest Inc. River Street dock receives cement, and has a water depth of 34 feet. The Louis Dreyfus Corporation Export dock ships grain, and has a water depth of 42 feet. Their Barge dock receives grain by barge, and has a water depth of 40 feet. The Portland Grain Terminal Barge Berth receives grain by barge, and has a water depth of 17 feet. Their Ship Berth (operated by Bunge) ships grain and has a water depth of 40 feet. Ross Island Sand and Gravel Co., Fremont Bridge Barge Mooring, receives sand and gravel by barge, and has a water depth of 12 feet. Columbia Aluminum Dock receives alumina and serves as a lay berth, with a water depth of 40 feet. Port of Portland Terminal 4, Automobile Unloading Dock Berth 416 receives automobiles, and has a water depth of 40 feet.

The Port of Portland's Terminal 4 Steel Handling wharf, Berths 414 and 415, are used for handling steel products, lumber, and receiving general cargo, with a water depth of 40 feet. Terminal 4, Pier 4, Berths 410 and 411, ship and receive dry bulk commodities, soda ash, and bentonite clay, and have a water depth of 40 feet. Terminal 4, Pier 2, Berths 406, 407, and 408, receive and ship general cargo, receive molasses, tallow and phosphoric acid, receive and ship liquid fertilizer, and have a water depth of 35 feet. Terminal 4, Roll-on/Roll-off Facility, Berth 408, receives and ships roll-on roll-off general cargo, and has a water depth of 35 feet.

The Port of Portland's Terminal 4, Pier 1, Berths 403, 404, 405 (Barge Unload Facility), are used for shipping and receiving liquid caustic soda and tallow, and receiving grain, with a water depth of 40 feet. Terminal 4, Pier 1, Berth 401 (Ship Berth), ships grain (operated by Cargill), and has a water depth of 40 feet. International Terminals Berth 4, Bulk Loader Dock, is used for shipping bulk commodities, scrap metal and petroleum coke, iron ore and mill scale, and has a water depth of 35 feet. Their Berth 1 Slip and Berth 2 Slip are used for loading and unloading third-party cargo and as a lay-up berth, with a water depth of 40 feet. Their Berth 3 Slip is used for a lay-up berth and storage berth, with a water depth of 40 feet. Premier Edible Oil Corporation Dock is used for receiving crude palm, coconut and palm kernel oil, and has a water depth of 42 feet.

The Time Oil Co. Rivergate Terminal Wharf is used for receiving and shipping petroleum products, and has a water depth of 35 feet. Western Transportation Co. Rivergate Barge Distribution Center receives and ships general cargo by barge, and has a water depth of 20 to 30 feet. Ash Grove Cement Rivergate Dock receives limestone by barge, and has a water depth of 25 feet. Unocal Petroleum Products and Chemicals Division Rivergate Dock receives granulated bulk urea, receives and ships anhydrous ammonia, ships caustic soda and sulfuric acid, and has a water depth of 35 feet. Port of Portland Terminal 5, Berth 503 Bulk Handling Wharf is a dry bulk handling facility, with a water depth of 40. Their Terminal 5 (operated by Columbia Grain, Inc.) receives and ships grain, and has a water depth of 40 feet at the face, and 15 feet at the rear of face.

The Port of Portland's Terminal 6, Berth 601, receives automobiles, and has a water depth of 40 feet. Terminal 6, Berths 603, 604, 605, receive and ship containerized general cargo and heavy lift items, with a water depth of 40 feet. Terminal 6, Berth 607, receives automobiles, and has a water depth of 35 feet. Vanport Pier receives sand and gravel by barge, with a water depth of 12 feet. Brix Rafting and Sorting Co. Mooring ships logs and general cargo, with a water depth of 10 feet at the bank, and 30 feet with dolphins. Miscellaneous docks include the Linnton Plywood Association Dock, log rafts, and several vessel moorage docks.

Industrial property includes: the Rivergate Industrial District with about 2,000 acres at the confluence of the Columbia and Willamette Rivers, site of Terminals 5 and 6; Portland International Center, 458 acres, adjacent to Portland International Airport; Port Center, 20 acres of waterfront property; Mocks Landing, 3.9 acres in the Swan Island area; and, Airtrans Center, 240 acres at the Portland International Airport.

The Portland Ship Repair Yard contains four docks, the largest of which has a lift capacity of 81,000 long tons, making it capable of handling a vessel up to 275,000 deadweight tons (dwt). The yard covers 125 acres, with 8,200 feet of repair and idle-ship berths. Dry dock one is 598 feet long with 88 feet clear width, and lift capacity of 15,000 long tons. Dry dock two is sectioned with pontoons to allow five independently operated sections. It is 514 feet long and has a 91.5 feet clear width, with a lift capacity of 12,500 long tons. Dry dock three is 661 feet long and 114 feet wide between wing walls, with 27,000 long ton lift capacity. The yard includes full support services for all aspects of ship repair and renovation.

4.3.2. Port of Vancouver

The Port of Vancouver, at about CRM 105, is the terminus of the deepwater channel of the Columbia and the beginning of upriver barge ports - the last port of import and first port of export for the interchange of waterborne commodities. Not only is the port accessible to major shipping lines and tug and barge companies, it also is adjacent to a major regional rail center served by two railroads. It is close to the Interstates 5, 205, and 84 and is less than 30 minutes from the Portland International Airport directly across the Columbia River.

The Port of Vancouver has several cargo docks. Vanalco Alumina Dock receives alumina, and has a water depth of 40 feet. Port of Vancouver Terminal No. 3, Lower Wharf, Berths 8 and 9 receive and ship conventional and containerized general cargo, with a water depth of 40 feet. Port of Vancouver, Dry Bulk Materials Loading Wharf, Terminal 2, Berth 7, ships dry bulk materials, and has a water depth of 40 feet. Port of Vancouver Oil Terminal Dock, Terminal 2, Berth 5, receives and ships petroleum products, receives liquid fertilizer and general liquid cargo, and has a water depth of 40 feet. Port of Vancouver Terminal 2 Upper Wharf, Berths 1, 2, 3, and 4 are used for conventional and containerized general cargo, dry bulk commodities, roll-on/roll-off cargo, automobiles in foreign and domestic trade, and heavy-lift commodities, with a water depth of 40 feet.

Vancouver Grain Elevator wharf (operated by United Grain Corporation) ships grain, and has a water depth of 40 feet. Port of Vancouver Terminal 4 receives automobiles, and has a water depth of 40 feet. Holnam Cement Vancouver pier receives cement, and has a water depth of 35 feet. Port of Vancouver Terminal 3 receives and ships breakbulk cargo, and has a water depth of 40 feet. Columbia Business Center dock is used for steel products and fabricated module shipments by barge and ship, for barge repair, and has a water depth of 25 feet. Tidewater West Vancouver dock receives and ships liquid bulk products, is used for barge maintenance and repair, has spill response and shoreside support capabilities, and has a water depth of 20 to 25 feet.

Port of Vancouver industrial properties include: Parcel 1A, with 85.2 acres, zoned heavy industrial; Parcel 1B, with 119.19 acres, zoned heavy industrial; Parcels 2 and 3, with 536.36 acres, zoned heavy industrial; Parcel 4, with 112.05 acres, zoned industrial park; and, Parcel 5, with 195 acres, zoned industrial park.

4.3.3. Port of Longview

The Port of Longview, located at approximately CRM 65, is a fully operational terminal port. Its facilities and services are designed to take advantage of its location as an effective interchange point between ocean, river, rail, and highway carriers. All of its 7-berth docking space (4,575 feet) is adjacent to the Columbia River, which at this point flows beneath the Lewis and Clark Bridge, which connects the port with Oregon. The seven berths have 40-foot draft along side. Behind the docks on 177 acres (660 more undeveloped), the port provides 17 warehouses with 1.6 million square feet of covered transit and storage space.

Berths 1 to 4 form one continuous wharf 2,355 feet long; berths 1, 2, and 3 are used for general cargo and dry bulk products; berth 4 is used for handling grain. Berth 5, with a 720-foot wharf, is used for handling petroleum coke and logs. Berths 6 and 7 form a wharf 1,500 feet long. This facility handles general cargo, including containers, roll-on/roll-off cargo trailers, and logs. This area is backed up by a 40-acre container yard with rail and highway access.

Other cargo docks at Longview include: the Reynolds Metals Co. Alumina dock with a berthing space of 700 feet and water depth of 38 feet; the Weyerhaeuser Company's Longview Plant Salt dock with a berthing space of 1,160 feet and a water depth of 32 feet, the Lumber Barge Loading dock with a berthing space of 300 feet and a water depth of 30 feet, the Cargo dock with a berthing space of 1,185 feet and a water depth of 35 feet, the Barge Slip with a berthing space of 320 feet and a water depth of 13 feet, and the Log Export wharf with 1,320 feet of berthing space and a water depth of 36 feet; the International Paper Co. Longview Wood Chip Export dock, with a berthing space of 1,440 feet and a water depth of 35 feet; and the Longview Fibre Company's Fuel Oil dock with a berthing space of 870 feet and a water depth of 40 feet and the Wood Chip dock with a berthing space of 2,360 feet and a water depth of 12 feet.

The port is involved in a development program that ultimately will provide greater facilities for barge handling, transloading, and cargo staging. Foremost among the port's cargo-handling equipment is the huge Columbia Giant, a 600-ton capacity crane. The Columbia Giant, at Berth 3, is backed by three multipurpose, electric-powered traveling gantry cranes on berths 1 and 2 with 50- and 60-ton capacities.

4.3.4. Port of Kalama

The Port of Kalama, Washington, is located on the right bank of Columbia River at CRM 75. The Port is served by the Burlington-Northern and Union Pacific railroads and Interstate

5, the main route to Portland and Vancouver, some 30 miles to the south. Federal navigation projects provided for the port consist of a 40-foot turning basin, and the 40-foot Columbia River channel fronting the port's facilities.

There are two grain elevators within the port district, Peavey and North Pacific Grain Growers. The Peavey Company grain elevator has a throughput capacity of approximately 10 to 12 million short tons annually (dockside depths range from 40 to 67 feet). The Harvest States Cooperatives Elevator ships grain from their dock, which has water depths ranging from 42 to 45 feet at the face and 40 feet at the rear of face.

Another existing facility is the Kalama Chemical wharf which receives shipments of toluene, and has water depths ranging from 40 to 50 feet. The port also has about 300 acres of land designated and in permit status for industrial use. The North Port site consists of 200 acres, with the first phase of the terminal completed (lay berth). The Port of Kalama Industrial Park, a 75-acre site, is zoned in the Comprehensive Plan as heavy or light industry. The Port of Kalama VCI site is a filled, 23-acre site, also zoned for heavy or light industry.

4.3.5. Port of Astoria

The Port of Astoria, located at CRM 12, has been dependent on logs for its major exports. Terminal Pier 1, Berth Face, and West Side are used for handling general cargo, and each have water depths of 40 feet. Terminal Pier 2, Berths 3, 4, 5, 6, and 7 ship forest and petroleum products, and have water depths of 35 feet. Terminal Pier 2, East Side, is used for general cargo and has a water depth of 40 feet. Terminal Pier 2, West Side, is used for general cargo, paper products, and seafood shipments, and has a water depth of 30 feet. Terminal Pier 2, Face, is used for general cargo and has a water depth of 30 to 35 feet. Rail and truck access is available to each pier.

Miscellaneous docks include cannery and seafood docks, Chevron fuel dock, Columbia Bar Pilots dock, marine supply dock, Maritime Museum wharf, mooring basin for small boats, U.S. Coast Guard Base dock, Astoria Oil Services moorage, National Maritime Union Job Corps Training Center and Corps of Engineers docks, and Astoria Marine Construction Co. docks. The Port of Astoria also has industrial property available.

4.3.6. Ports of St. Helens and Woodland

The Ports of St. Helens and Woodland are located at CRMs 85 and 80, respectively. The Port of St. Helens has two main docks. The Pacific Western Forest Industry Dock is used for shipment of wood chips by barge and for log rafts (water depth is 20 feet). The Boise Cascade Corporation Paper Division Dock is used for shipment of bulk woodpulp and rolled paper products and receives fuel oil for plant consumption (water depths range from 3 to 21 feet). The Port of St. Helens has industrial property available. The Port of Woodland has no marine facilities, but have industrial property available.

5. WATERBORNE COMMERCE

Economic activity associated with maritime commerce on the lower Columbia River is dominated by agriculture. The Columbia River provides access to a large hinterland area where a variety of products and commodities are produced.

The major growing areas for wheat and barley that is exported from the Columbia River include Oregon, Washington, Idaho, western Montana and portions of North Dakota. The major competition for the regional wheat and barley trade is the Puget Sound ports, since the portion of the grain that comes in by rail can be fairly easily diverted to the Seattle area. The inland mode of transportation by which wheat and barley move to Columbia River Export Houses does vary from year to year. In general, however, about 53 to 57 percent moves by rail, about 40 to 43 percent moves by barge, and about 1 to 3 percent moves by truck (source: *Columbia River System Operation Review DEIS*, *Appendix O*, July 1994).

The major growing area for the corn exported from the region is the Midwest, particularly Nebraska, Minnesota and South Dakota, although smaller amounts originate within the region. The corn is moved from the Midwest to the Columbia River for export primarily by rail. The Gulf ports are the primary competition for corn, because it can be moved by a barge network that uses the rivers of the Midwest, such as the Mississippi, Missouri, Red, and Ohio Rivers, downstream to the Gulf for export. Two railroad companies operate corn trains from the upper Midwest to the Pacific Northwest. These companies are Burlington Northern, which collects corn shipments from the North and South Dakota and western Minnesota areas, and Union Pacific, which collects corn shipments from Nebraska and western Iowa. Both companies route their trains to Vancouver, Washington. At Vancouver, the corn trains are routed either 120 miles northwest to the ports of Tacoma and Seattle, or are sent 30 miles west to the Port of Kalama, Washington which is the major corn export facility on the Columbia River.

Historically, the Columbia River system has been known as an export system primarily for agricultural and forest products. A wide variety of cargoes have been containerized for export. Containers for export originate primarily in Oregon, Washington, and Idaho. Being an export system has led to Portland being used as a last port of call for most of the container lines servicing Portland. As a last port of call container lines assign ships a higher number of container slots allocated for outbound traffic than for inbound traffic. (Typically, ports are designated as first ports of call when they serve a major population center, and container lines can unload large volumes of containers destined for the large local market, as well as other intermodal destinations.) Portland does receive imported containerized traffic, but it is quite small compared to export traffic. Currently, most of the containerized cargo imported through the Port of Portland is consumed in the local market.

Major countries involved in the region's export trade area include Japan, Taiwan, Korea, Pakistan, and the Philippines. Import trade is conducted worldwide, but the major countries in the region's import trade area include Australia, Japan, Mexico, and Canada.

Table 6 displays a 10-year history of commodity tonnage for specific commodities moved on the Columbia River: wheat, barley, corn and milo, other feed grains, containers, alumina, and other dry bulk commodities (source: Portland Merchant's Exchange, provided by Port of Portland).

As the statistics show, wheat exports have varied up and down over the 10-year period, but the general trend shows an increase over the period. Wheat is exported primarily from Portland and Vancouver, with less than ten percent exported from Kalama. 1997 wheat exports were at a 10-year low, and, given the current Asian economic situation, it is possible that, in the short term, exports will continue to be low. Barley shows more extreme variations in export tonnage from year to year. Barley is exported primarily from Portland and Kalama, with occasional exports from Vancouver. Corn exports from the Columbia increased markedly when the Peavey facility was built at Kalama, in the early 1980's. Corn is exported primarily from Kalama, with occasional exports from Portland. Alumina imports have varied up and down over the 10-year period. In general, the largest alumina tonnage is imported by Vancouver, followed by Longview, then Portland. The trend for containers shows increases in tonnage over the 10-year period. The export traffic exceeds the import traffic by a large margin, although the specific ratio varies from year to year. Portland is the center for container traffic on the Columbia River.

Table 6. Columbia River Tonnage History

(thousands of short tons)

Commodity	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Wheat	10,442.6	15,073.5	11,350.3	11,569.5	12,103.6	12,534.5	12,221.6	15,328.0	14,852.4	13,909.9	9,634.8
Barley	1,736.5	856.9	469.5	715.2	628.2	425.7	458.8	215.7	1,060.3	594.8	980.8
Corn	4,271.3	5,797.6	7,048.2	6,968.2	4,498.9	3,942.0	3,287.6	1,888.8	7,968.2	4,905.9	4,771.9
Ore – Alumina	1,314.4	1,630.4	1,713.1	1,750.9	1,830.2	1,368.6	1,232.3	1,138	1,375.6	1,245.6	1,145.1
Container TEUs[(1)]											
Outbound	99,590	115,431	124,304	107,901	118,413	138,038	171,664	221,142	226,413	200,693	186,633
Inbound	40,234	49,175	61,723	55,032	57,487	62,862	67,775	96,819	103,335	101,478	108,297
Total	139,824	164,606	186,027	162,933	175,900	200,900	239,439	317,961	329,748	302,171	294,930
Container Short Tons [(2)]											
Outbound	1,393,222	1,592,705	1,648,844	1,440,014	1,626,735	1,826,529	2,240,898	2,926,421	2,993,400	2,737,986	2,654,157
Inbound	262,940	263,217	231,550	196,461	202,714	328,178	297,285	418,132	432,658	408,115	501,513
Total	1,656,162	1,855,922	1,880,394	1,636,475	1,829,449	2,154,707	2,540,176	3,346,547	3,428,053	3,148,097	3,157,667

Source: Portland Merchant's Exchange

(1) Includes empty containers

(2) Includes container tare weights, includes empty containers

5.1. Commodity Forecasts

Commodity forecasts comprise one critical element of the feasibility study. The commodity forecasts are used in conjunction with fleet forecasts to determine transportation costs for proposed alternatives. It is assumed that existing navigation operating practices would be utilized in both the without- and with-project conditions. Commodity projections were made for a 50-year project life (year 2004 to 2054) and include containers, wheat, corn, barley, and alumina. Wheat, corn, and barley are export commodities, alumina is an import commodity, and containers are import and export commodities (although containers are primarily exported). The projections for each commodity are estimated for each major trade route (region), and no tonnage would be induced or transferred by any of the proposed alternatives. The following sections summarize the commodity forecasts. The actual commodity forecast, due to the volume of that document, is not included with this document, but is available upon request.

Due to the long term nature of the Channel Improvement Study, most of the work on the commodity forecasts was actually completed in 1995. This document does attempt to update those forecasts given current information. The most notable two occurrences to date are the Asian currency crisis and the nuclear weapons testing in Pakistan, triggering trade sanctions with Pakistan. Pakistan is a major wheat importer, and congress acted quickly to exempt wheat exports from the imposed trade sanctions. As for the currency crisis, it is possible that, in the short-term, exports will see a decline, but it is likely that these economies will have recovered by 2004, the first year any deepening alternative will be in place. For further discussion of the impacts of potential reductions in export quantities, see the Risk and Uncertainty section.

5.1.1. Containers

Container cargo represents a significant percentage of the total tonnage moved through the Columbia River. According to the Columbia River Transit Data Base provided by the Port of Portland, container exports from the Columbia River in 1993 were 1,873,020 short tons or approximately 7 percent of the total export tonnage. Added to this were an additional 148,322 short tons of imported container cargoes. The only container port in the lower Columbia River is the Port of Portland. Portland is somewhat unique among the West Coast ports in that it is almost exclusively an outbound container port. Outbound movements are dominated by more resource-based, lower value-added products than are inbound movements, which is consistent with the pattern throughout the West Coast. The Port of Portland has traditionally been a last port-of-call on outbound container voyages across the Pacific Ocean. As a result, exports account for approximately 90 percent of total container throughput.

The commodities and origins/destinations handled by the Port of Portland are very similar to those handled in Puget Sound. On the export side, much of the cargo base is composed of forest products (paper, paperboard, lumber, fiberboard, particleboard) and agricultural products (hay, animal feeds, potatoes, corn and meat), as well as waste paper and other manufactured products (auto parts among others). On the import side, consumer goods dominate container trade and include products such as toys, tires, footwear, apparel, computer parts, consumer electronics, and furniture, as well as manufacturing goods. From 1985 to 1994, container traffic increased at an average annual rate of 9.7 percent. The most likely container growth scenario maintains Portland at constant market share by major trade route relative to other West Coast ports. Using regional container models, an average annual growth rate of 2.8 percent is projected throughout the period of analysis, as shown in Table 7.

Table 7. Export Projections for Containers

Year	Outbound TEUs*
1995	219,538
2000	288,525
2004	332,802
2010	406,334
2014	457,093
2024	611,575
2034	803,936
2044	1,048,785
2054	1,351,421

* Twenty-foot Equivalent Units, full.

For the purposes of calculating transportation costs, the projection is converted to short tons, using a factor of 11.8 short tons per TEU, excluding the weight of the container, based on detailed examination of 1993 movements. Further, as the benefit analysis distinguishes between container vessels using Portland as a last port of call on the West Coast and those container vessels using Portland as a middle port of call, the export projection, based on historical data, is divided accordingly. Seventy percent of Columbia River container exports depart using Portland as a last port of call.

Further, given that container vessels almost always have additional cargo on board from previous west coast port calls, the projection is adjusted to reflect that all tonnage on board each vessel has the potential to benefit from a deepening of the Columbia River channel. For last port of call vessels, approximately 1.026 short tons of cargo are on board for every short ton loaded at Portland. For mid-port vessels, the ratio is 2.223.

Given those adjustments, the following table displays the total benefiting tonnage for both last-port and mid-port container vessels.

Table 8. Total Benefiting Container Tonnage

(short tons)

Year	Last Port Benefiting Tonnage	Mid-Port Benefiting Tonnage
2004	5,569,369	3,797,077
2014	7,649,350	5,215,169
2024	10,234,553	6,977,713
2034	13,453,671	9,172,438
2044	17,551,168	11,966,025
2054	22,615,702	15,418,928

In 1996 and 1997, container exports dropped from a 1995 high of 226,000 TEU's to 200,000 and 186,000 respectively. It is likely, given the currency situation in Asia, that 1998 exports could be lower as well, however, this analysis assumes that the Asian economies will recover during the next five years, and that, by 2004, growth in trade will have resumed. The possibility of long-term reductions in the container trade with Asia is addressed in the risk and uncertainty analysis (Section 9).

5.1.2. Wheat

Wheat is the leading commodity, in terms of tonnage, moved by the deep-water ports on the Columbia River. Wheat accounted for over 50 percent of total export tonnage from the ports in 1993. Table 9 displays historic wheat shipments from Columbia River ports.

Table 9. Historic Wheat Exports

Year	Tons Exported
1987	10,443,000
1988	15,074,000
1989	11,350,000
1990	11,570,000
1991	12,104,000
1992	12,535,000
1993	12,222,000
1994	15,328,000
1995	14,852,000
1996	13,910,000
1997	9,635,000

The Columbia River ports should expect healthy growth in wheat traffic. Growth would be fueled by trade with Asia and somewhat moderated by the low growth rates of Japan. This trend would be expected to continue until sometime between 2024 and 2034 when Asian countries reach their maximum per capita wheat consumption, and population growth rates slow.

There are three major trade routes used in the wheat export projection. The ‘rapidly developing Asia’ region includes South Korea, Taiwan, Singapore, Malaysia, Indonesia, and Thailand. This region would be expected to see a rapidly rising demand for wheat until 2035 when it should level off. In the near term, this is driven largely by strong economic growth, rising incomes, rapid industrialization and urbanization, and limited ability to produce wheat domestically. The economic growth, which has been fueled largely by exports, provides the foreign exchange necessary to expand wheat imports.
In the ‘Southeast Asia’ region, wheat use has increased by nearly 50 percent in the 1990s, growing at a rate of almost 10 percent per year from 1990 to 1994. Rising disposable income has resulted in a more diverse diet with the substitution of Japanese-style noodles for rice. Many regional experts believe that the per capita wheat use ceiling for the region would likely be similar to Japan. However, Malaysia is already at this level with one-tenth the per capita income. Indonesia could experience the most rapid growth in import demand since the country's largest flour miller and noodle processor has started a large expansion program. If fully utilized, processing capacity would require nearly 7.0 million tons of wheat, more than doubling the 3.25 million tons imported in 1994-1995.

Although the ‘Other Asia’ region contains more than thirty countries in Asia, the Philippines, Pakistan, and Sri Lanka are the three major destination countries. These countries currently receive more than 30 percent of Columbia River wheat exports. Wheat export growth to the Philippines would be expected to remain strong. The Philippines imports its total supply of wheat, and most comes from the United States (91.2 percent market share in 1993-1994). Growth in Philippine wheat consumption is steady and high. Population growth is strong (2.2 percent from 1990-1995) and would likely continue to be among the highest in Asia until slowing to 1.4 percent in 2010 to 2015 (WEFA, 1995). Per capita consumption has also grown steadily, up 50 percent over the last 10 years to about 26 kilograms (about 57 pounds). This trend could continue through the end of this century but should experience some slowing as consumption rates exceed that of the Japanese.

Table 10 displays projections for Columbia River wheat exports throughout the period of analysis. Twelve percent of the wheat would be exported to countries outside of the rapidly developing Asia and the other Asia regions. These exports to countries in Africa, Latin America, and the Middle East would be expected to remain at a steady share of total exports from the Columbia River.

Table 10. Export Projections for Wheat

Year	Tons Exported
2004	14,518,651
2014	14,729,680
2024	15,972,270
2034	19,065,140
2044	19,427,940
2054	19,427,940

While 1997 Columbia River wheat exports were at a low 9.6 million short tons, it is not expected that the figure represents a long-term change in the global wheat market. While the economic troubles in Asia could result lower wheat exports in 1998 and 1999, it is expected that demand will recover, and that the projections are sound in the long-term.

5.1.3. Corn

After wheat, corn represents the second largest tonnage commodity shipped through the Columbia River ports. According to the Portland Merchants Exchange/Columbia Snake River Marketing Group, in 1993 corn accounted for 12.9 percent of total export tonnage from the ports, which was a relatively weak year for corn exports. Exporting of corn through the ports is a relatively recent phenomenon. The first year of significant corn exports was 1984, with the opening of the Peavey grain elevator at Kalama.
Growth in corn exports from the Columbia River is tied to the high growth in feed grain consumption in the rapidly developing Asia region and Japan. Corn exports from the Columbia River are very concentrated, with Japan, Korea, and Taiwan accounting for all but a very small percentage. Japan's share of Columbia River corn exports would eventually drop to 12 percent, while rapidly developing Asian countries would eventually receive approximately two-thirds of the total.

In China, the feed sector is expanding very rapidly and feed mill output has doubled since 1987. Double-digit growth would be unlikely to continue. Nevertheless, the underlying factors that drive the demand forecasts would continue. Rising consumer incomes, working spouses, and a more open market and social environment raise expectations and generate more demand for meat, eggs, snack, and convenience foods. As discussed for wheat, China has the fastest growing economy in the world with high per capita income growth. However, population growth would be expected to moderate and drop from 1.2 percent annually (1990-1995) to less than 1 percent per year after 2005. Income growth, which has experienced double-digit rates, would moderate but remain relatively high. Most observers see a continuing gap between production and consumption and a need to import. China is projected to receive 15 percent of Columbia River corn exports in 2004, increasing to 21 percent by 2054.

In the rapidly developing Asia region, Taiwan, South Korea, and Malaysia would all be expected to experience economic growth, leading to increased meat consumption and increased demand for feed grains. Many of these countries are also improving infrastructure to allow efficient use of large grain carrying vessels, which should increase the competitive status of United States exports. Table 11 displays the projections for Columbia River corn exports throughout the period of analysis.

Table 11. Export Projections for Corn

Year	Tons Exported
2004	4,654,000
2014	5,438,000
2024	6,374,000
2034	8,425,000
2044	8,680,000
2054	8,785,000

5.1.4. Barley

Barley represents the third largest tonnage commodity shipped through the ports on the Columbia River. Barley accounted for 1.8 percent of total export tonnage from the ports. As shown in Table 12, exports of barley from the Columbia River can be highly volatile. Typically, barley exports were between 450,000 and 950,000 short tons per year. This volatility mirrored United States barley export behavior during the same period.

Barley is used primarily as an alternate feed grain in the world market as well as for malting. Typically, barley represents a relatively small fraction of total United States coarse grain production (5 to10 percent). Destinations and volume vary from year to year. The export projections for barley are shown in Table 13 and represent a modest growth rate over the period of analysis.

Table 12. Historic Barley Exports

Year	Tons Exported
1985	350,000
1986	911,000
1987	1,872,000
1988	871,000
1989	664,000
1990	722,000
1991	603,000
1992	332,000
1993	461,000
1994	225,000

Table 13. Export Projections for Barley

Year	Tons Exported
2004	899,000
2014	983,000
2024	1,086,000
2034	1,043,000
2044	1,064,000
2054	1,064,000

5.1.5. Alumina

Alumina, an import commodity primarily shipped from Australia (86 percent in 1993), is a basic material for aluminum smelters in the area. Alumina is one of the leading import commodities by tonnage moved through the deep-water ports on the Columbia River. Competition with other ports would not be an issue for alumina importation since local smelters use the entire product. In fact, many of the smelters have their own docks. Also, since virtually all of the alumina in the region is imported from Australia, a country-level forecast was not necessary.

Forecasts predict that Pacific Northwest smelters would continue to operate at approximately 85 to 90 percent of their capacity throughout the next 30 years. While some plant modernization would occur to meet environmental regulations and to become more competitive internationally, the projection assumes no expansion of local capacity (Table 14). Therefore, even in a modest growth scenario there would be limited opportunity to expand alumina imports to meet growing demand as would be possible for other commodities. With increasing competitive pressures, there would be a possibility of further declines in the future, although the current outlook should be at least stable.

Table 14. Import Projections for Alumina

Year	Tons Imported
2004	1,344,819
2014	1,344,819
2024	1,344,819
2034	1,344,819
2044	1,344,819
2054	1,344,819

6. FLEET FORECASTS

The fleet forecast attempts to determine the extent that vessels calling at the Columbia River ports will make use of any channel improvement. The fleet forecast reflects the trade-route specific analysis performed for the commodity projections. For each commodity, each major trade route has been examined to determine what forces would dictate the size of vessels calling on the ports.

Examination of Columbia River departure drafts from previous years provides a perspective on the way that vessels have responded to channel deepening in the past (Tables 14 and 15). The Columbia River channel had an authorized depth of -35 feet CRD from 1935 until 1962. In 1963, work on the 40-foot channel was started. The 40-foot channel was essentially completed in 1972. During the course of the ten-year period of deepening, maximum drafts increased, as well as the number of vessels in the deeper draft ranges.

The Waterborne Commerce statistics show a shift of five feet in maximum vessel operating drafts (from 34 to 39 feet) in response to deepening the channel from -35 to -40 feet CRD. In 1962, 12.75 percent of the vessel operating drafts were 30 feet or deeper (540 vessels ranging from 30 to 34 feet). By 1972, 20.4 percent of the vessel operating drafts (825 vessels) were in the range from 30 to 34 feet, and an additional 2.76 percent (112 vessels) were in the deeper range from 35 to 39 feet (as a result of the deeper channel), totaling 23.16 percent of vessel operating drafts (937 vessels) that were 30 feet or deeper.

The next major improvement to the Columbia River was the deepening of the mouth of the Columbia River to 55 feet, which was authorized in 1983 and completed in 1984. In 1983, prior to deepening, two 40-foot draft vessels (0.05 percent), eleven 39-foot draft vessels (0.30 percent), and thirty-eight 38-foot draft vessels (1.03 percent) called on the Columbia River. Statistics for 1984 show that there was a significant increase in the number of vessels calling at the deeper drafts: fourteen 40-foot draft vessels (0.36 percent), sixty-one 39-foot draft vessels (1.56 percent), and sixty-five 38-foot draft vessels (1.67 percent). During 1985, the river forecasting system *Loadmax* came on line. In 1985, twenty-two 40-foot draft vessels (0.62 percent), fifty-three 39-foot draft vessels (1.49 percent), and seventy-five 38-foot draft vessels (2.11 percent) called on the Columbia River.
To summarize, there was a visible shift to deeper vessel operating drafts as a result of the previous 5-foot channel deepening. With the additional improvements to the mouth of the Columbia River project and the use of *Loadmax*, deeper drafting vessels made increased use of the 40-foot channel. Both the actual number of vessels and the percentage of vessels with deeper drafts have continued to increase in recent years. It is anticipated that there would be a similar fleet response to further channel deepening. An increasing number of vessels are pushing up against the depth constraints of the existing 40-foot channel. Some users have indicated that they would make use of a deeper channel, if available, to bring deeper draft vessels to the Columbia River, and to load those vessels which are currently calling to deeper drafts.

6.1. Container Fleet

The container fleet on the Columbia River will continue to increase in terms of both design and departure drafts. Cargo demand and competition will drive the fleet on the West Coast. The fleet will also benefit from a worldwide trend toward container vessels with increasing capacity. As 5,000 TEU vessels are deployed in Asia-Europe trade, +4,000 TEU vessels are being rotated to the West Coast. The container fleet calling Portland is already beginning to be impacted by channel constraints.

The Port of Portland provided a database detailing Columbia River traffic in 1993. This database is very detailed with data on destinations, tonnage carried, and design and departure drafts among other things. This 1993 database is the primary source used to identify the current fleet and operating practices. The port provided supplemental information on 1994 and 1995 traffic. This data is less detailed but did provide departure drafts and vessel names (which were used to identify design drafts). This 1994 and 1995 data is used to supplement the 1993 database where it is useful in the analysis. All design drafts have been converted to freshwater, and all deadweight tonnage has been converted to short tons (unless otherwise noted).

Table 15. Columbia River Historical Fleet by Departure Draft and Year

Draft	35-foot Channel 1962	40-foot Channel 1972	1983	MCR 55 feet 1984	Loadmax 1985	1986	1987	1988	1989	1990
44				1						
43										2
42										1
41										14
40			2	14	22	28	20	50	63	52
39		3	11	61	53	44	36	28	34	54
38		4	38	65	75	58	120	156	88	62
37		15	53	46	63	47	59	73	57	116
36		45	58	60	82	73	137	217	148	139
35		45	128	112	116	120	138	171	187	178
34	3	69	216	195	143	142	189	174	212	209
33	21	138	226	238	103	149	173	202	252	257
32	77	245	183	275	162	231	320	251	316	272
31	264	167	182	141	120	174	158	170	138	138
30	175	206	188	189	185	160	141	172	202	163
29	193	169	181	175	165	219	148	138	148	117
28	187	147	190	174	171	184	180	201	203	150
27	183	181	242	212	233	190	198	220	145	181
26	242	271	192	205	208	185	211	242	235	232
25	306	259	231	235	251	229	232	226	221	241
24	358	284	226	266	241	225	233	214	235	207
23	439	352	239	242	244	240	249	238	215	171
22	464	354	200	247	223	241	227	254	208	175
21	408	355	200	204	203	248	256	260	192	236
20	508	373	280	305	318	402	314	347	381	415
19	411	364	222	237	181	174	172	198	171	176
SUM	4239	4046	3688	3899	3562	3763	3911	4202	4051	3958

Table 16. Columbia River Historical Fleet Distribution by Departure Draft and Year

Draft	35-foot Channel 1962	40-foot Channel 1972	1983	MCR 55 feet 1984	Loadmax 1985	1986	1987	1988	1989	1990
44				0.03%						
43										0.05%
42										0.03%
41										0.35%
40			0.05%	0.36%	0.62%	0.74%	0.51%	1.19%	1.56%	1.31%
39		0.07%	0.30%	1.56%	1.49%	1.17%	0.92%	0.67%	0.84%	1.36%
38		0.10%	1.03%	1.67%	2.11%	1.54%	3.07%	3.71%	2.17%	1.57%
37		0.37%	1.44%	1.18%	1.77%	1.25%	1.51%	1.74%	1.41%	2.93%
36		1.11%	1.57%	1.54%	2.30%	1.94%	3.50%	5.16%	3.65%	3.51%
35		1.11%	3.47%	2.87%	3.26%	3.19%	3.53%	4.07%	4.62%	4.50%
34	0.07%	1.71%	5.86%	5.00%	4.01%	3.77%	4.83%	4.14%	5.23%	5.28%
33	0.50%	3.41%	6.13%	6.10%	2.89%	3.96%	4.42%	4.81%	6.22%	6.49%
32	1.82%	6.06%	4.96%	7.05%	4.55%	6.14%	8.18%	5.97%	7.80%	6.87%
31	6.23%	4.13%	4.93%	3.62%	3.37%	4.62%	4.04%	4.05%	3.41%	3.49%
30	4.13%	5.09%	5.10%	4.85%	5.19%	4.25%	3.61%	4.09%	4.99%	4.12%
29	4.55%	4.18%	4.91%	4.49%	4.63%	5.82%	3.78%	3.28%	3.65%	2.96%
28	4.41%	3.63%	5.15%	4.46%	4.80%	4.89%	4.60%	4.78%	5.01%	3.79%
27	4.32%	4.47%	6.56%	5.44%	6.54%	5.05%	5.06%	5.24%	3.58%	4.57%
26	5.71%	6.70%	5.21%	5.26%	5.84%	4.92%	5.40%	5.76%	5.80%	5.86%
25	7.22%	6.40%	6.26%	6.03%	7.05%	6.09%	5.93%	5.38%	5.46%	6.09%
24	8.45%	7.02%	6.13%	6.82%	6.77%	5.98%	5.96%	5.09%	5.80%	5.23%
23	10.36%	8.70%	6.48%	6.21%	6.85%	6.38%	6.37%	5.66%	5.31%	4.32%
22	10.95%	8.75%	5.42%	6.33%	6.26%	6.40%	5.80%	6.04%	5.13%	4.42%
21	9.62%	8.77%	5.42%	5.23%	5.70%	6.59%	6.55%	6.19%	4.74%	5.96%
20	11.98%	9.22%	7.59%	7.82%	8.93%	10.68%	8.03%	8.26%	9.41%	10.49%
19	9.70%	9.00%	6.02%	6.08%	5.08%	4.62%	4.40%	4.71%	4.22%	4.45%
SUM	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

6.1.1. Operating Scenarios for Portland Container Vessels

The operating scenario defines the primary assumptions used to forecast the fleet in the with- and without-project condition. The operating scenario explicitly describes the conditions that will effect the fleet forecast and serves to focus the analysis.

Container vessels serving Portland would continue trafficking predominantly the transpacific routes. Currently, 97 percent of Portland container traffic is transpacific as is 90 percent of West Coast container traffic. The major transpacific trade routes will continue to be Northeast Asia with Southeast Asia increasing over time. In 1995 Northeast Asia was 86 percent of traffic through Portland. In 2054, Northeast Asia is expected to be 78 percent of traffic as Southeast Asia increases its market share. Foreign port depths are not expected to be a significant limiting factor for Portland container traffic given that most have deeper salt water drafts and the fact that all ports seem to give priority to maintaining and constructing depths for container vessels.

The Port of Portland would continue to be primarily an export port and would continue to be a last port of call for 70 percent of cargo loaded. The other 30 percent will move on middle port of call vessels. These middle port of call vessels have historically departed at shallower depths and are expected to continue this practice in the future. These vessels call Puget Sound (+49-foot depth) as their last port of call, departing there at their maximum draft. Since these vessels will depart their last port of call near their design draft, benefits of the Columbia River channel deepening can only be claimed for the journey at a deeper draft to the Puget Sound. It is assumed the containership would have left the Puget Sound at the same draft with or without the project. Since these vessels carry a small percentage of the tonnage, have not historically taken advantage of the current channel depth, and would only benefit on the trip to the Puget Sound, middle port of call vessels make up very little of the benefiting fleet. Cargo loaded at Portland and already on board for vessels that are last port of call will be the principal benefiting container tonnage. This is because this tonnage will benefit from the deeper draft from Portland to the foreign destination port.

Container lines interviewed stated that inbound drafts are not a current concern and that they do not expect inbound drafts to be a concern in the future. Only one inbound container vessel had a draft above 36 feet in 1995.

Ninety percent of the container tonnage moved through Portland is export cargo. It is preferred as a last port of call because of the relatively short sailing distance to Japan and Korea. The relatively small population base deters shippers from calling Portland as a first port of call. Exports are expected to remain predominantly natural resource based forest and agricultural products. Based on forecasts, container traffic would continue to grow at an annual average growth rate of 3 to 4 percent per year through Portland (source: Jack Faucett Associates, *Columbia River Channel Deepening Feasibility Study Commodity Projections*, February 1996).

Current export cargoes from the Columbia River include hay, animal feed, paper products, lumber, and other food (frozen potatoes, corn, and peas). On the import side, consumer goods dominate container trade with products such as toys, tires, footwear apparel, consumer electronics, furniture and manufacturing inputs such as auto parts. Because Portland exports a large amount of raw materials while importing mostly finished products, the containers are usually loaded heavier for export than import. Based on traffic in 1993, a TEU for export contained 11.8 short tons of cargo (excluding tare weight and empty containers) while an import TEU contained 6.6 short tons.

Like all container movements in general and more specifically transpacific movements, competition between lines will be intense. Rationalization among carriers should continue and expand in scope. Lines calling Portland will change ports, order of calls, and routing patterns in an attempt to increase profits. Carriers will also seek to utilize economies of scale by moving to faster vessels with more carrying capacity. In 1993 average vessel capacity was 2,700 TEUs. Based on interviews with major container lines calling Portland, TEU capacity is expected to increase to around 3,500 TEUs by 2004. Vessels with a TEU capacity of under 2,000 TEUs will be phased out in the future, and the trend toward increases in TEU capacity will continue. Vessels with design drafts of 39 feet and greater will continue to service Portland. During 1995, 80 percent of the container vessel movements were in vessels with designs drafts at or above 39 feet.

Most container vessels will continue to depart at drafts less than the design draft. This is the result of cargo capacity constraints, depth constraints, and the availability of cargo. Based on interviews with container lines calling Portland, 4 feet and occasionally 5 feet of underkeel clearance will be requested in all alternatives. In the without-project condition, vessels will target to have a departure draft of 36 feet. Most departure drafts will not increase beyond 36 feet in the without-project condition as few container lines are willing to wait to ride the tides. With a 43-foot channel, few vessels are expected to depart significantly beyond 39 feet for the same reason. The time dependency of container traffic will not lend itself to delays in operations caused by tides both in the with- and without-project conditions. Container ships operate on demanding schedules that usually require them to arrive at a particular port at a specific time on a specific day of the week. Any delay can have a negative effect on the coordinated rail and truck transportation of cargoes. A ship delay can have a domino effect delaying other ships scheduled to call at this and other berths. Also delays can cause unacceptable congestion in the marine terminal. Because of the severe impacts of delays, containership operators strive to avoid them at the expense of loading the ship less deeply to ensure an unrestricted transit. One container line currently calling Portland is an exception. It targets departure drafts significantly beyond 36 feet and is willing to incurring delays. In the with- and without-project conditions, this practice is expected to continue.

Based on Port of Portland information and development plans, it is assumed that land-side and other facilities for service containers will be enhanced and upgraded as necessary to develop and maintain a viable and prosperous container market. The Port of Portland has recently acquired land for the long-term development of a new additional container terminal.

6.1.2. Age

Age is not a significant factor in the projected fleet of container ships. Most of the container ships are fairly new. In the 1993 Columbia River container fleet, there were only three vessels older than 15 years. These three vessels do not call Portland regularly and carry less than 1,500 TEUs. This type of vessel will not call Portland in any significant numbers in the future and is likely to be phased out of service in the Pacific Northwest because of economies of scale. Over 90 percent of the container ships were less than 10 years old.

Despite this, a comparatively large number of the new build orders are for container ships. Although the life of container ships (20 to 25 years) are significantly less than bulk vessels as the result of the high speeds that increase wear and tear on the container ships, economic efficiency is driving the replacement of vessels through Portland. Today, the increasing volumes of containers to be carried and the need to keep costs low to compete drive the investment in larger ships for the Pacific Northwest and not the scrappage of container ships. Based on interviews conducted with the shippers in the spring of 1995, the major shipping lines of Evergreen, Hyundai, and NYK expect to have larger ships calling within the next two years. Some of these container vessels will be new, while others will be redeployments to the region. Redeployments are still expected to bring vessels that are less than 15 years old. The cycle on vessel deployments is expected to be less than ten years for vessels under 3,000 TEUs. Hyundai is replacing its 2,000 TEU vessels with 3,000 TEU vessels after only four years calling Portland and expects to have their 4,400 TEU vessels calling Portland before 2004. By the time channel construction will be completed (2004), it is anticipated that a majority of the vessels will have design drafts that exceed 40 feet.

Figure 1 displays the delivery profile of different types of container ships over the last twenty years. The panamax (+3,000 TEU with Panama Canal dimensions) and post-panamax (+4,000 TEU exceeding Panama Canal dimensions) are relatively new deliveries of panamax and post-panamax vessels have been ramping up and are at historical highs in 1995. This contrasts with the sub-panamax (2,000 - 2,999 TEU) vessels where deliveries appear to have peaked in the mid-1980s and are decreasing. Vessels serving Portland should mirror this world trend to larger vessels.

6.1.3. Volume

One of the fundamental factors driving the move to larger container ships is the dramatic increase in volume, particularly on the West Coast. Between 1984 and 1993, container movements showed an average annual growth rate of 8.2 percent for the Port of Portland. The West Coast average annual growth rate over this same period was 6.8 percent. This heavy growth in traffic is a function of the growing trade with Asia. This increasing volume of traffic is expected to continue. DRI, which makes projections for the Port of Portland, estimates that container traffic will grow at an annual average rate of 5.8 percent till 2010 (the end of their analysis period). Over this same period, Faucett (1996) projects container traffic to grow at an annual average rate of 4.0 percent for the Port of

Portland. Over the total study period (2004 to 2054), container traffic is expected to quadruple according to the projections (Figure 2).

Another factor in the volume of vessel calls is the change from random to weekly scheduled service that was implemented in the 1980s. This drove the need for many new vessels, route consolidation, and improvements in vessel service speed.

Figure 1. Container Ship Deliveries by Year and Type

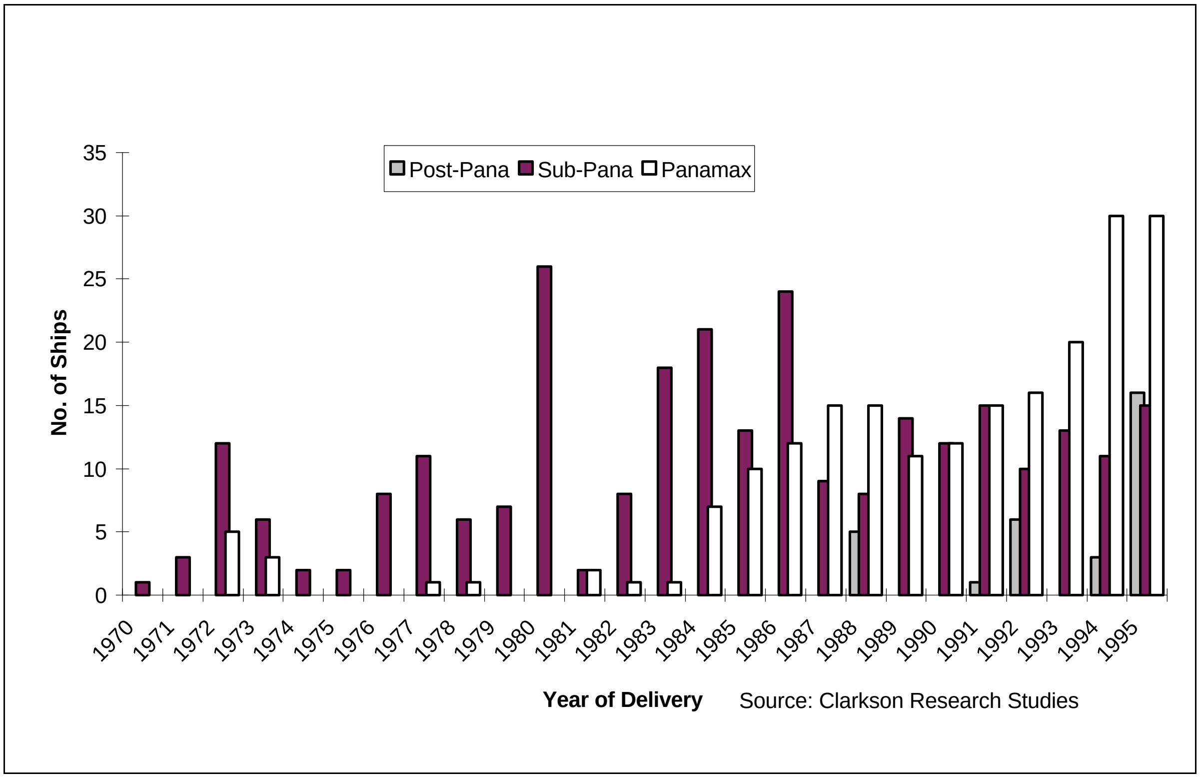
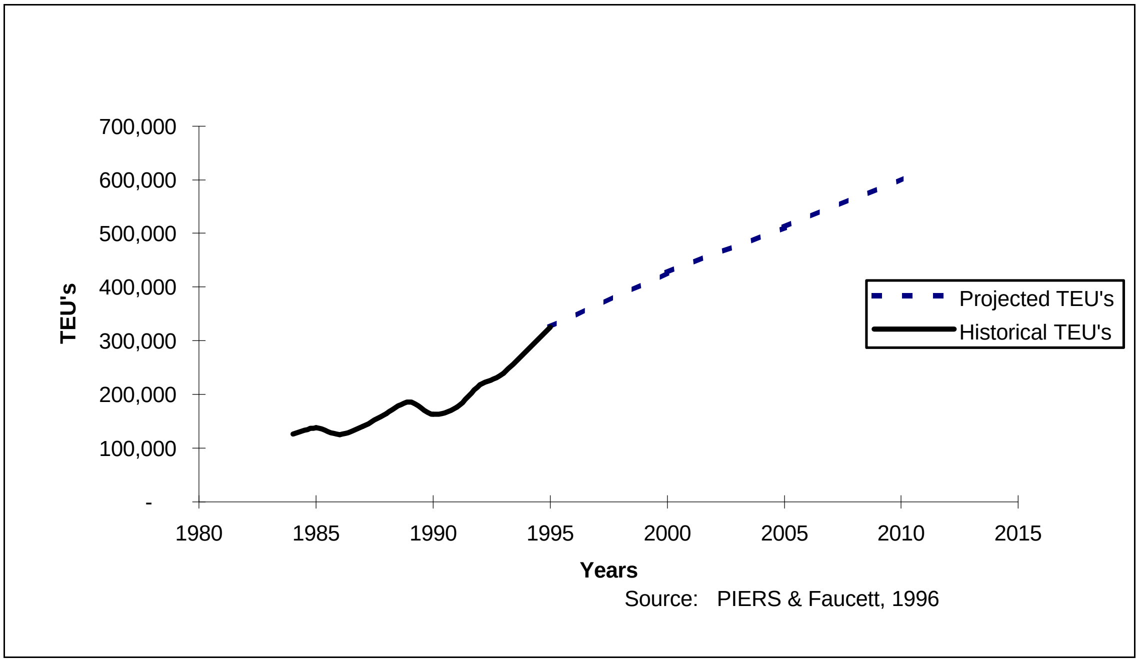


Figure 2. Historical and Projected Containers for the Columbia River



Other studies have noted the trend towards growing container traffic through the Pacific Northwest. The Savannah District in cooperation with USDOT, Maritime Administration in 1993 did a study called, *The Future Market for Containership Traffic in the South Atlantic Region of the United States*. In the analysis of the total trade forecast, the Pacific (Oregon, Washington, Alaska, Hawaii, California) is expected to increase its market share of total U.S. inland trade by seven percent from 1990 to 2050. This is the largest gain of any area. Also, the study projects that the Pacific is expected to gain the largest market share of U.S. exports, growing from 32 to 36 percent from 1990 to 2050. Again the Pacific leads all other areas of the country in the growth of market share for exports.

The increasing container movements are a result of a surge in international trade in the Far Eastern economies along with the continued economic growth in the West. As of 1995, transpacific trade accounts for more than 90 percent of containerized trade on the West Coast and approximately 56 percent of total U.S. international trade. The two major trade routes in the transpacific trade include Northeast Asia (i.e. Japan, Korea, Taiwan, Hong Kong, and People's Republic of China) and Southeast Asia (i.e. dominated by Thailand, Malaysia, Singapore, Indonesia, and the Philippines). Northeast Asia accounted for 5.0 million TEUs in trade with the U.S. as a whole in 1993 while Southeast Asia accounted for 1.0 million TEUs. According to data from PIERS, over 97 percent of the Port of Portland's container movements are transpacific shipments. Table 16 shows the destination ports for container movements from Portland in 1993.

In addition, the trend towards containerization should contribute to higher volumes. This trend is a continuation of the early 1980s trend, but at a slower pace. Several factors add to increasing containerization. The recent development of economical refrigerated containers will lead to increasing containerization of temperature sensitive cargoes. Another factor is the need to fill excess capacity on container ships. Shippers are driven to find containerized cargo to keep rates on the larger vessels competitive. Finally, the rapidly developing countries will move increasingly toward containerization. Malaysia and Vietnam are currently constructing their first container facilities.

In 1986, container traffic made up 10 percent of the vessels calling on the Columbia River. In 1993, container traffic makes up 16 percent of the vessels calling on the Columbia River. The total carrying capacity of the container vessels calling Portland increased between 1986 and 1993 by 241 percent. This is an annual average rate of growth of 13 percent. This is the result of both the increasing number of calls and the increased carrying capacity of vessels calling Portland. In 1986, the total DWT was 4,589,371 short tons with 188 vessel calls for an average DWT per vessel of approximately 24,412. In 1993, the total DWT was 11,076,908 short tons with 245 vessel calls for an average DWT per vessel of 45,212. The average DWT of a vessel calling the Columbia River in 1993 has nearly doubled since 1986. In 1986, the 188 container calls on the Columbia River were done with 54 vessels. In 1993, the 245 vessel calls were done with less than 55 vessels. Tables 18 and 19 outline the change in the fleet composition from 1986 to 1993.

Table 17. Portland Container Cargo – 1993

Foreign Port-Exports	Short Tons	TEUs	Foreign Port-Imports	Short Tons	TEUs
Tokyo, Japan	410,073	36,975	Kaohsiung, Taiwan	31,064	3,412
Kaohsiung, Taiwan	301,591	24,180	Hong Kong, Hong Kong	24,460	5,421
Kobe, Japan	254,987	21,667	Tokyo, Japan	18,282	2,924
Busan, S. Korea	190,854	14,240	Busan, S. Korea	15,269	2,036
Nagoya, Japan	169,716	16,221	Keelung, Taiwan	9,656	1,386
Hong Kong, Hong Kong	140,930	12,246	Kobe, Japan	9,122	1,146
Osaka, Japan	121,156	10,116	Dadiangas, Philippines	5,020	298
Keelung, Taiwan	72,879	6,376	Nagoya, Japan	3,806	365
Shimizu, Japan	56,596	4,774	Yokohama, Japan	3,147	705
Hakata, Japan	52,038	4,338	Singapore, Singapore	2,435	275
Yokohama, Japan	50,724	4,379	Osaka, Japan	1,376	153
Singapore, Singapore	6,038	420	Hakata, Japan	954	164
Other Ports	483	37	Other Ports	1,417	131
Total	1,828,064	155,970	Total	126,008	18,417
Other Non-Far East Ports	39,750	N/A	Other Non-Far East Ports	15,509	N/A

Source: Journal of Commerce - PIERS

Table 18. Container Vessels Calling the Columbia River - 1986

Year Built	Average DWT	Average Design Draft	Average TEU Capacity	Number of Vessels
1986	---	---	---	---
1985	37,924	37.91	2,333	8
1984	43,249	38.05	2,728	4
1983	31,429	37.42	1,689	31
1982	---	---	---	---
1981	20,802	37.04	1,292	6
1980	25,586	35.52	1,396	14
1979	22,096	34.52	1,342	9
1978	28,068	34.64	1,039	13
1977	16,859	30.54	818	2
1976	16,835	30.54	818	4
1975	---	---	---	---
1974	25,067	35.40	1,353	13
1973	25,883	35.65	1,240	22
1972	27,213	35.98	1,412	11
1971	25,702	34.84	971	12
1970	25,022	34.23	934	35
< 1970	20,647	32.11	896	4
			TOTAL	188

Table 19. Container Vessels Calling the Columbia River – 1993

Year Built	Average DWT	Average Design Draft	Average TEU Capacity	Number of Vessels
1993	63,628	41	4,229	9
1992	42,030	38	3,072	22
1991	44,324	38	2,865	40
1990	48,711	38	2,680	11
1989	41,054	35	2,136	9
1988	53,558	38	3,265	28
1987	50,660	38	3,058	24
1986	44,504	39	2,548	34
1985	38,614	38	2,027	41
1984	47,841	38	2,728	3
1983	47,617	38	2,728	6
1982	---	---	---	---
1981	20,982	33	970	1
< 1980	35,896	37	1,140	2
			TOTAL	245

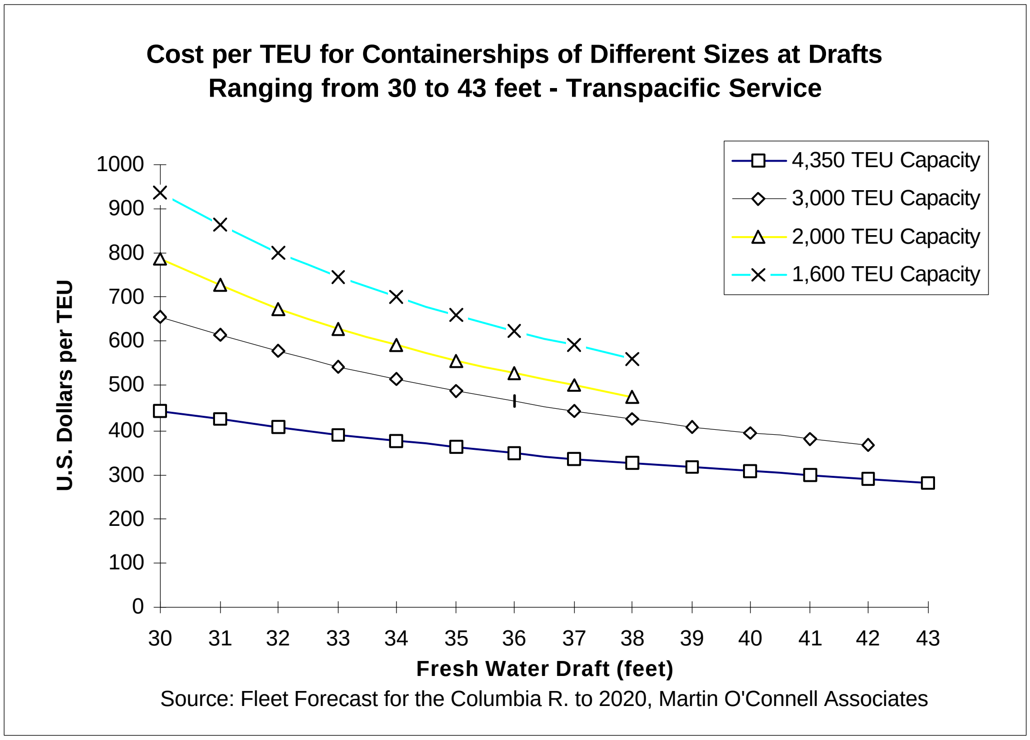
6.1.4. Economics

In order to keep their costs competitive, ship lines have been forced into seeking efficiencies. Today, both the increasing volumes of containers to be carried and the need to cut costs to compete justify investment in larger ships. Owners are driven by economies of scale to build large efficient ships and lay up older, smaller, and more costly to operate ships. Since the early 1970s, the cargo capacity of container ships has steadily grown with a corresponding change in ship dimensions.

The deep sea container ship is designed to transport the maximum load of container boxes as fast and as economically as possible between terminals. Because a container ship can be loaded and discharged rapidly with high-speed gantry cranes, the annual productivity of these ships is much higher than that of freighters, which carry the same commodities but require more time to load and discharge. Most container ships operate in liner services and maintain very tight schedules. With operating speeds ranging from 21 to 24 knots, container ships are the fastest of all commercial cargo ships. To maximize their load, container vessels have small deadweight tonnage when compared with their dimensions and with their registered tonnage, as would be expected with a vessel built to handle a volume commodity. At the present time vessels larger than 3,500 TEUs represent approximately 21 percent of the total capacity of the top 20 container carriers. However, new orders are virtually all for larger vessels; 96 percent of the new vessel capacity on order equals or exceeds 3,500 TEU capacity for the top 20 container carriers (source: 1995 Marine Cargo Forecast).

The introduction of larger vessels in the major container trade (i.e., transpacific, transatlantic, and Europe-Asia trade routes) is expected to exert a continued downward pressure on container rates as carriers scramble to fill capacity. This is demonstrated by westbound container rates for lumber from Seattle to Japan that have declined from $1,657 per 40-foot container in 1992 to $1,397 in September 1994 (source: average rates according to Lloyds Shipping Economist). Figure 3 taken from the Fleet Forecast for the Columbia River to 2020 that was done by Martin O'Connell Associates for the Port of Portland, shows the dramatic differences in required freight rates for different container vessel sizes. This difference for a 3,000 TEU and a 4,350 TEU vessel can be as much as $200 per TEU or a 33 percent reduction in rates. For larger variances in vessel sizes, the cost difference can be even more dramatic. In the June 1995 Marine Log, it is reported that, "Global economic growth of nearly 3 percent, with substantially higher figures in the Asia/Pacific region, are encouraging factors, but the continuing over-supply of tonnage has continued to depress freight rates except in some of the dry bulk markets." Conditions like this are expected to continue into the future. This will continue to put pressure on shipping lines to exploit efficiencies that can be achieved by employing larger vessels.

Figure 3



6.1.5. Facilities

The Port of Portland, like most container facilities on the West Coast, is expanding and updating their container services to meet the increasing demand. In 1994, the Port Commission approved a $25 million program to improve the terminal's truck gate, increase the size of the container yard, and improve the efficiency of the layout. In addition, the Port of Portland has completed a development study for West Hayden Island. The port's development program envisions three phases of development. Phase I (1996-2005) will be for a 120 acre grain export terminal. Total investment in Phase 1 will be $102 million. Phase 2 will include an intermodal rail yard, highway access bridge, and container terminal. This phase of construction will cost $323 million and is scheduled for 2005-2010. Phase 3 includes a second container facility with a cost of $186 million. The need for Phase 3 is anticipated after the year 2020.

Currently at the Port of Portland's main container terminal (Terminal 6), two post-panamax cranes service container traffic in addition to five other panamax cranes. The Port has hired engineering design consultants to prepare plans and specifications for extending the outreach (boom lengthening), raising, and narrowing two of its Hitachi panamax cranes so that they can be converted to serve post-panamax vessel dimensions.

Terminal 6 is a state of the art container facility and compares favorably to other West Coast terminals. The terminal has three berths dedicated to ship loading and unloading and one berth for inbound barged containers. Terminal 6 has open storage of 63 acres. The rail yard used by the container terminal is modern. There are two on-dock intermodal rail yards with capacity of 62 double stack cars and direct access by Union Pacific and Burlington Northern Railroads. The Portland rail facilities have less congestion problems than other larger ports allowing them to send/receive cargo to/from the East Coast quickly. The port is optimistic that they will gain a higher share of imports in the future because of their rail facilities. The estimated throughput capacity of existing Terminal 6 facilities is approximately 560,000[3] TEUs annually. As evidenced by Evergreen's decision to call Portland with its post-panamax vessel, Portland should continue to be an attractive port for large container ships.

6.1.6. Departure and Design Drafts

The departure drafts have increased rapidly over the last few years. The target draft for container vessels is 36 feet based on 1993 operating practices. This is the depth that provides the necessary underkeel clearances such that container vessels can depart without incurring any delays. Because of the relatively small market, departure and design draft data can be heavily influenced in Portland by the loss of lines or changes in last port. However, as can be seen in figure 4, the trend appears to be toward deeper departure drafts. In 1993, vessel departure drafts peaked around 34 feet. In 1995, the departure drafts are approaching the 36-foot target draft. Any container vessel that wants to depart at drafts beyond 36 feet must receive pilot approval and ride the tides.

Table 20 shows the trend toward increasing average departure drafts for container vessels that used Portland as last port of call. Except for the last row, the table shows all the container vessels that have called Portland in the last three years that had at least three calls in a given year. It shows that the increase in departure drafts is not necessarily tied to new vessels. Many of the vessels calling here previously are now able to fill their vessels more completely. The last row in the table is all the other container vessels that either did not call on the port in each of the three years or made less than three calls in a year. The table again shows the dramatic increase in departure drafts in the last three years. It also indicates that many of the vessels currently calling Portland as well as those not calling Portland consistently are loading deeper and encountering channel constraints.

[3] Port of Portland.

Figure 4

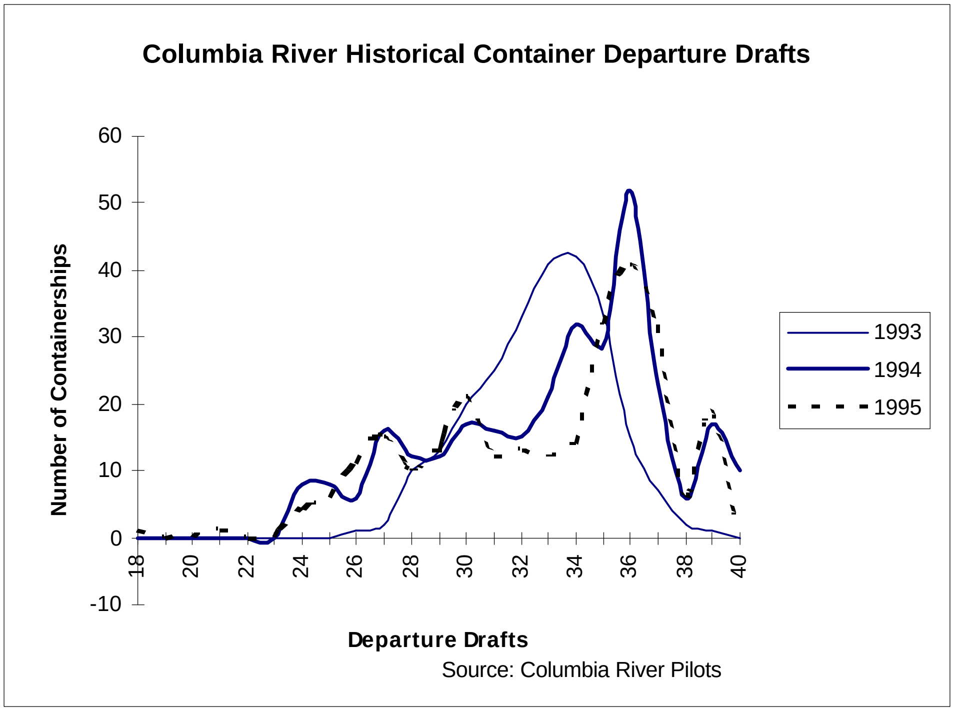


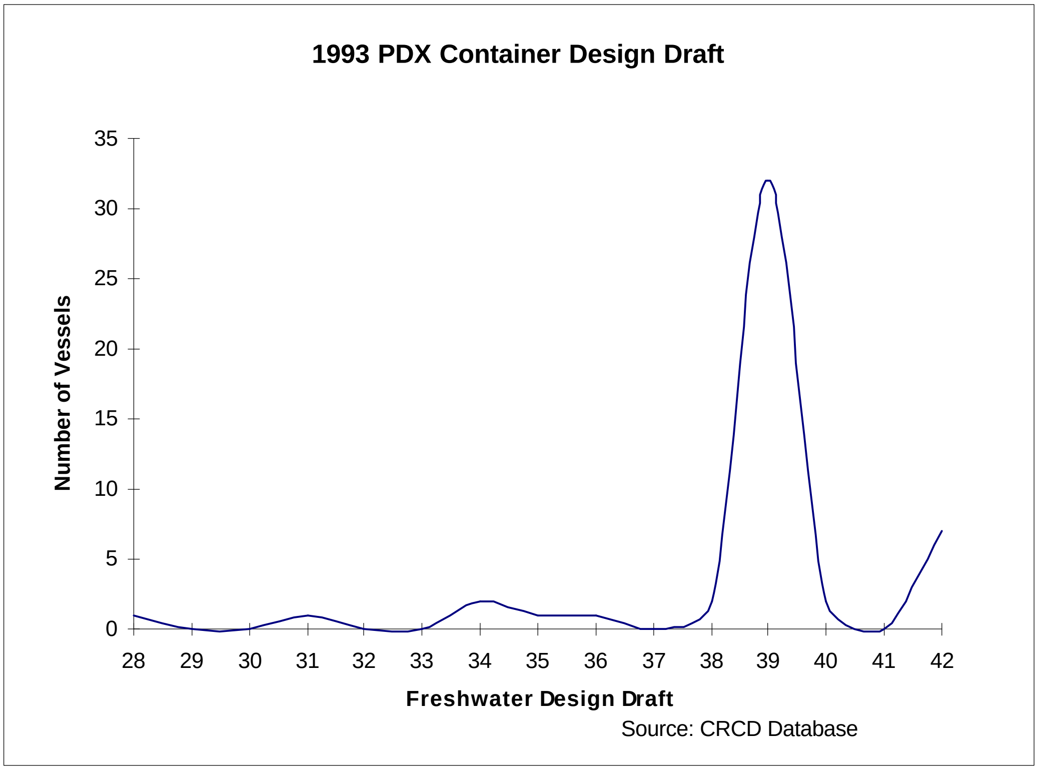
Table 20. Container Vessel Average Departure Drafts - Last Port of Call

Vessel Name	1993	1994	1995
Bay Bridge	33.6	35.5	36.0
Ever Gallant	31.8	34.8	36.9
Ever Right	34.3	37.8	38.9
Ever Royal	34.0	38.5	39.0
Golden Gate	33.8	34.8	34.6
Hanjin Bremen	33.0	35.1	36.2
Hanjin Hamburg	32.3	33.0	36.8
Hanjin Rotterdam	31.0	36.0	36.7
Hanjin Seattle	33.3	35.9	35.6
Hanjin Vancouver	31.3	35.1	35.1
Harbour Bridge	34.2	34.1	34.6
Tower Bridge	33.8	35.2	36.0
Transworld Bridge	32.5	33.7	33.4
Other Cont. Vessels	33.4	35.9	36.7

Another factor contributing to the deeper departure drafts is the design drafts for container ships. Of the 1993 container fleet calling Portland, over 95 percent of the vessels have design drafts of 39 feet or greater. This indicates that a large portion of the container vessels currently calling Portland could potentially take advantage of a deeper channel. Thirty-nine feet is also the predominant design draft for the world fleet. As of 1993, the only other design draft where there is more than 5 vessels is at 42 feet. Figures

5 and 6 show the design drafts of container vessels calling Portland in 1993 and the world container fleet in 1994, respectively.

Figure 5



It is common for container vessels on transpacific routings to have deeper design drafts. The vessels do not have to transit the Panama Canal, which is draft restricted at 40 feet (tropical fresh water). These large container vessels bring goods from Asia to the West Coast. The vessels usually drop off significant tonnage in California or the Puget Sound and work their way up/down the coast, increasing cargo onboard as they go. Portland is often a last port of call for these vessels before they head back to Asia. It is expected that design drafts will continue to increase at Portland as large container ships on order for companies serving Portland move into service. Table 21 shows the historical increase in design drafts for container vessels using the Columbia River.

Figure 6

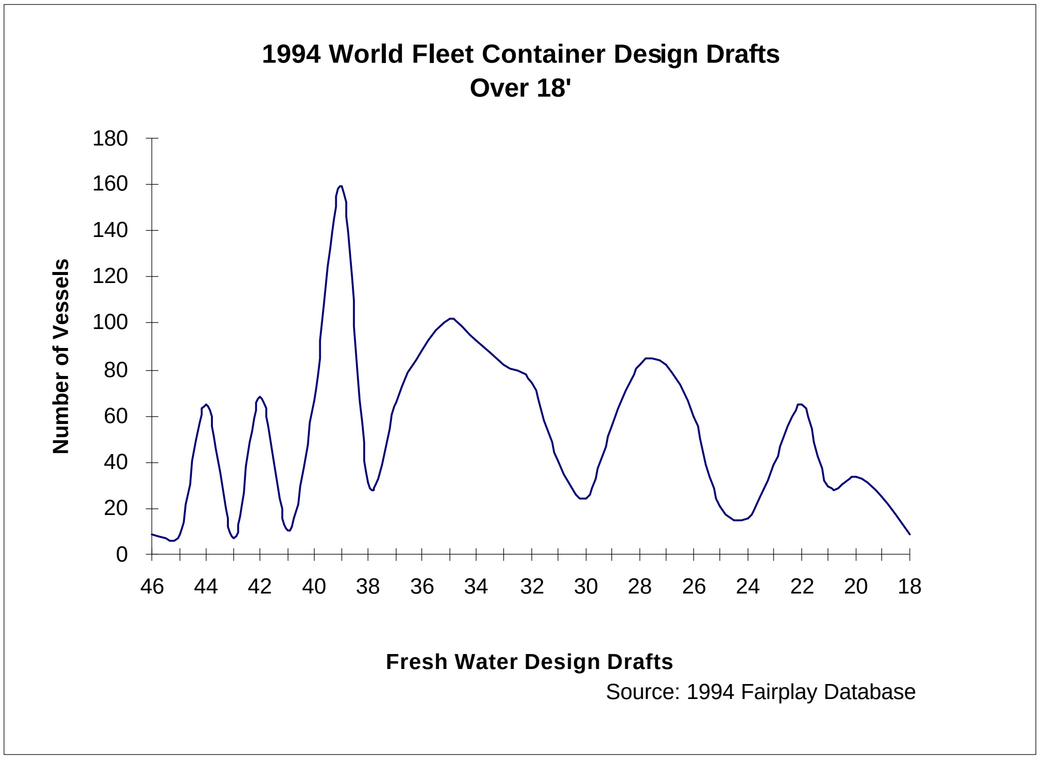


Table 21. Columbia River Container Vessel Characteristics: Number and Percentage of Vessels by Design Draft, 1965 – 1993

Draft (feet)	1965		1970		1975		1980		1986		1993	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Less than 30	0	0	1	33	6	40	10	27	0	0	1	2
30 – 39.99	0	0	2	67	9	60	27	73	33	100	39	80
40 - 49.99	0	0	0	0	0	0	0	0	0	0	9	18
50 or more	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	3	100		100	37	100	33	100	49	100

Source: Deep Draft Fleet Projection, Gulf Associates, 1988 updated with 1993 port information.

6.1.7. Container Lines

The following paragraphs outline the container fleet calling Portland in 1993 to 1995. The 1993 information was part of a detailed database on vessel traffic provided by the Port of Portland at the origination of the study. In addition, the 1993 information was updated with limited data provided by the Port for 1994 and 1995[4].

[4] Due to the study schedule, fleet forecasts were actually produced in 1996, meaning that some of the discussion of container lines is no longer accurate, but the nature of the container industry is relatively

6.1.7.1. Hanjin Ships

The pattern for Hanjin ships is to call Seattle and then call Portland before heading overseas to Yokohama, Japan. Most ships have approximately a 2,700 TEU capacity and have fresh water design drafts of 39 feet. Fourteen different vessels from Hanjin called Portland in 1993. Twelve of the fourteen vessels were constructed between 1986 to 1991. The other two vessels were constructed in 1972. In 1993, all of Hanjin ships left Portland at a draft below 35 feet and 97 percent left at a draft of 34 feet or less. Hanjin made 35 calls to Portland in 1993. Hanjin continued to provide last port of call service to Portland in 1994 and 1995. During that time departing vessel drafts increased. In 1995, 28 Hanjin vessels sailed with drafts exceeding 36 feet. In March 1996, Hanjin discontinued its Portland call[5].

6.1.7.2. NYK Line

From 1991 to 1993, NYK served Portland with two weekly vessels calls. The Pacific Northwest Service (PNX) made Portland its last port of call after calling Seattle and Vancouver, B.C. The second service, the Far East Express (FEX) initially call Portland as last port after calling at California ports and Seattle. In 1993, FEX shifted its last port call to Seattle, making Portland a mid port call. TEU capacities range from 1,000 to 3,000 TEUs with over 75 percent of the vessels having a capacity of over 2500 TEUs. All vessels except one have a design draft of 39 or 42 feet. Thirteen different vessels called Portland in 1993. All vessels were constructed between 1980 to 1992. In 1993, 30 percent of NYK ships left at a draft of 35 feet or greater and 9 percent left at a draft greater than 36 feet. NYK made 102 calls to Portland in 1993.

In November 1994, NYK Line discontinued its PNX service and was thus reduced to a single weekly call to Portland with the FEX service. The FEX service has continued to call Portland as a mid-port. NYK Line's partners on the FEX service are Neptune Orient, Hapag-Lloyd, and P&O Container. There are no announced plans to change vessel deployment at this time.

6.1.7.3. Evergreen Ships

The pattern for Evergreen ships is to call San Francisco and then Portland before heading to Tacoma. The TEU capacity ranges from 2,700 to 4,200 and all have a design draft of 39 feet or better. Ten different vessels called Portland in 1993. All vessels were constructed between 1983 to 1993. In 1993, 16 percent of ships departed at a draft of 35 feet or greater and 4 percent departed at a draft of 36 feet. Evergreen made 51 calls to Portland in 1993.

Evergreen made Portland its last port of call in May 1994, dropping Tacoma from its schedule. From this point until June 1995, Evergreen sailed from Portland at drafts consistently between 39 and 40 feet. In mid 1995, Evergreen replaced its 4,300 TEU'R'

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fluid, and, while the lines and vessels sometimes change from year to year, the overall fleet projections have not changed.

[5] Hanjin has since reestablished service in Portland.

class vessels with its 3,400 TEU "GX" class vessels. Evergreen will deploy its 4,900 TEU post-panamax "U" class vessels to Portland in June 1996. At that time, Tacoma will be added to the schedule as last port and Portland will become a mid-port.

6.1.7.4. K-Line Ships

The pattern for K-Line ships is to call Tacoma and then call Portland before heading to Tokyo. The TEU capacity ranges from 2,000 to 2,900 and all have a design draft of 39 feet or better. Six different vessels called Portland in 1993. All vessels were constructed from 1980 to 1986. In 1993, 37 percent of K-Line vessels left at a draft of 35 feet or greater and 8 percent left at drafts of 36 feet or greater. K-Line ships made 52 calls to Portland in 1993.

In 1994 and 1995, K-Line has continued to call Portland as last port of call. K-Line's partner in its Portland service is Yang Ming Line; Hyundai Merchant Marine also participates on a slot-charter basis. K-Line has no announced plans to deploy different vessels at the present time.

6.1.7.5. Hyundai Ships

Hyundai initiated direct Portland service in April 1994, deploying vessels with about 2,000 TEU in capacity with design drafts ranging between 36 and 38 feet. The Hyundai rotation is very unique: Seattle - Portland - Seattle. Portland is thus a mid-port of call. The Hyundai vessels typically depart Portland with drafts of less than 30 feet. Hyundai has announced its intentions of deploying its "Challenger" class vessels to Portland during the second part of 1996. These vessels have capacities of 3,000 TEUs and design drafts of 42 feet. K-Line participates in the Hyundai service under a slot charter arrangement.

Because the container industry is very dynamic, lines frequently change routing patterns or last port of call to take advantage of opportunities. Portland has been no exception. In 1995, Hanjin and Mitsui OSK decided to drop service to Portland in favor of Vancouver B.C. Hanjin alone was 14 percent of container traffic. Some have questioned how quickly the Port can recover from a loss of this magnitude. Given the history of the port and the nature of the market, it seems likely the Port will regain this traffic rapidly. Portland has recovered from the loss of major carriers before and is expected to recover from this one. When Matson left Portland in 1988, it was 20 percent of Portland's container volume. Portland recaptured the lost market and went on to post double digit container growth through the first half of this decade.

Given the competitive nature of the container industry, relocation of shipping lines can be expected. Mitsui OSK pulled out of Portland in 1990, came back and is now pulling out again in 1995. In 1992, three new lines began calling Portland Hanjin, Hyundai, and MedPacific. Two new carriers have signed on since the announced pull out of Hanjin. These lines are not expected to replace the volume Hanjin moved. However, the addition of these lines along with the other historical movements do show that the current market is dynamic and carriers can be expected to make frequent changes. In addition, the export cargo that Hanjin and Mitsui OSK moved will continue to come from the Port of Portland's hinterland. It will now be railed to the Puget Sound for inclusion on Hanjin and Mitsui's call there. Port of Portland carriers have already expressed an interest in trying to recapture this cargo. The port estimates that over 80 percent of export cargoes are local or regional cargoes.

6.1.8. Destinations

Because of the high value cargo associated with container movements, ports endeavor to have maximum port depths available for container vessels. Also since most of the destination ports are salt-water ports, vessel sinkage will be less. Given this and the considerable depths currently available or planned, destination depths are not expected to constrain the container fleet calling Portland with or without the project. Tokyo is the largest importer of containerized cargo, receiving 22 percent of container cargo exported from Portland in 1993. Tokyo's current salt-water depth is 42.5 feet. There is currently construction planned to deepen Tokyo harbor to 46 feet. Currently, 90 percent of Portland's containerized exports are bound for ports with depths of 42.5 feet or deeper according to PIERS data for 1993. Table 22 shows the limiting draft at the Port of Portland's primary destination ports for containers.

Table 22. Depths at Container Destination Ports

(all drafts in salt water)

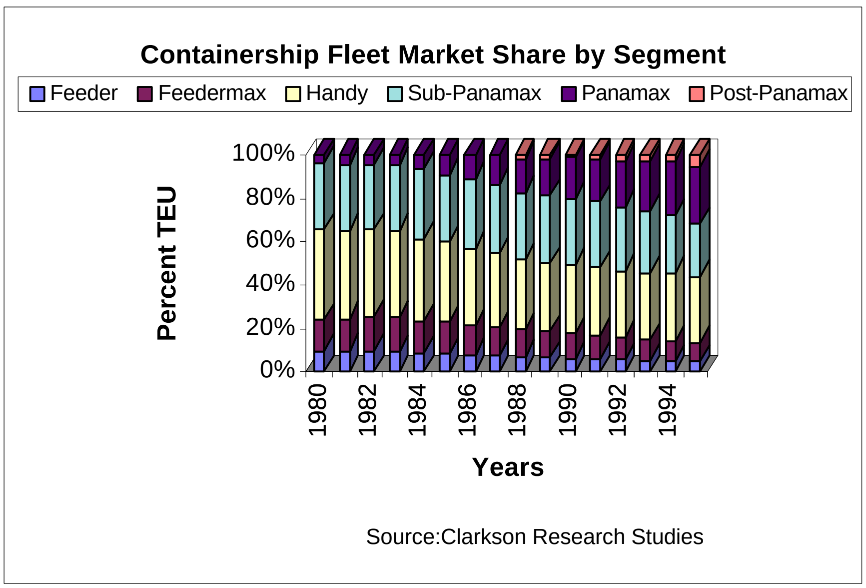
Country	**Port**	**Constraint**
Japan	Tokyo	42.5
	Kobe	45.9
	Nagoya	46.0
	Osaka	42.5
	Shimizu	39.4
	Hakata	38.7
	Yokohama	42.7
Taiwan	Kaohsiung	45.9
	Keelung	42.3
Korea	Busan	46.0
Hong Kong	Hong Kong	46.0
Singapore	Singapore	46.0
United States	Long Beach	45.0
	Los Angeles	45.0
	Oakland	42.0
	Seattle	60.0
	Tacoma	50.0+
	Oakland	42.0
Canada	Vancouver BC	50.0+

Source: Journal of Commerce - PIERS, Containerization International Yearbook, and Lloyd's Ports of the World 1994.

6.1.9. The World Fleet

During the period 1980 to 1995, the world containership fleet grew at an average of 9.9 percent per annum in terms of TEU capacity. In the last two years the growth rate of the containership fleet has exceeded the mean, with a 10.2 percent increase in 1994 and 13.5 percent growth recorded in 1995. This is well above the trend so far in the 1990s which shows fleet growth of just 7.9 percent. The containership fleet market share by segment chart gives a good indication of the growing importance of panamax and post-panamax vessels. As shown in figure 7, container tonnage is increasingly being handle by the larger panamax and post-panamax container ships. The TEU capacity of post-panamax vessels has more than doubled from 1994 to 1995. Sixteen new vessels were added in 1995 to the fleet of fifteen vessels in 1994. The TEU capacity of panamax class vessels has been growing over 15 percent per year for the last eleven years. From 1994 to 1995 TEU capacity for panamax vessels increased by 21 percent. The percentage of TEUs being moved by all of the smaller vessels is decreasing. The average age of the container fleet is 12 years. The panamax and post-panamax fleets are both very young, with average ages of 5.3 years and 1.9 respectively. This again shows the shift towards the larger capacity container ships. The average design draft for the panamax and post-panamax fleet is 42 feet and 44 feet, respectively. As more vessels of these sizes are rotated into Portland, draft constraints will be a problem.

Figure 7



The existing fleet of post-panamax container vessels are all less than ten years old. More post-panamax vessels are on order today than currently exist. The first vessels of this size appeared in 1988 and by the end of 1995 the fleet had grown to 31 vessels of 142,000 TEU, with an additional 46 vessels of 233,720 TEU on order. Post-panamax vessels are called post-panamax because their beams exceed the lock capacity and they can no longer use the Panama Canal. These vessels carry over 4,000 TEUs and have an average design draft of 44.5 feet. The ships on order possess 165 percent of the TEU carrying capacity of the existing post-panamax fleet. Order book activity indicates that post-panamax vessel construction will be very intense over the next few years. The average vessel currently is 4,579 TEU although the vessels on order for delivery in 1996 average 5,135 TEU. For 1997 delivery the average is 4,981 TEU (Table 22).

Another important factor to consider in the fleet forecast is the draft of larger capacity vessels. Vessels that used to draft 42 feet and carry 2,500 TEUs are being constructed to draft 42 feet and carry 4,000 TEUs. The design draft for Hanjin's new 5,000 TEU vessel is 40.5 feet and 42 feet for their 6,000 TEU vessel. Hyundai's new 5,500 TEU vessel is expected to draft 42 feet. It is hard to tell if this is an industry trend or the design specifications of a few particular carriers. Certainly some larger vessels are being constructed that draft comparably deep. OOCL and APL/OAK are both constructing vessels with design drafts of 47 feet and carry less than 5,000 TEUs. For this analysis it is assumed that it will continue to be mixed, as some large capacity vessels will have deep design drafts and others will draft relatively shallow.

Table 23. Post-Panamax Fleet Statistical Summary

	Existing Fleet Age Range (Years)							Orderbook (Delivery)	
Item	**≥ 25**	**20 - 24**	**15 - 19**	**10 - 14**	**5 - 9**	**0 - 4**	**TOTALS**	**1996**	**1997 +**
Total No.	----	----	----	-----	5	26	31	22	25
Total TEU	----	----	----	-----	21,700	120,238	141,938	112,650	125,870
Total Dwt	----	----	----	-----	273,385	1,649,692	1,923,077	1,308,900	1,548,600
Av. Size TEU	----	----	----	----	4,340	4,625	4,579	5,120	5,035
Av. Size Dwt	----	----	----	----	54,677	63,450	62,035	59,495	61,944
percent of Flt No.	----	----	----	----	16.1	83.9	100	71	80.6
percent of Flt TEU	----	----	----	----	15.3	84.7	100	79.4	88.7
Av. LOA m.	----	----	----	----	275.2	284.7	283		
Av. Beam m.	----	----	----	----	39.4	37.7	38		
Av. Draft m.	----	----	----	----	12.6	13.3	13.2		
Av. Speed	----	----	----	----	24.2	24.1	24.1		

Source: Clarkson Containership Register 1996

The panamax container fleet is defined by Clarkson as all container vessels over 3,000 TEUs up to 4,000 TEUs that can transit the Panama Canal. The average design draft of these vessels is 42.1 feet. Currently there are 207 of these panamax vessels with a cumulative carrying capacity of 753,953 TEUs. Ninety-five percent of these vessels are less than fifteen years old. There are 61 panamax vessels on order with a cumulative carrying capacity of 234,000 TEUs. Within the panamax vessels, average TEU carrying capacity is increasing. The average TEU capacity of the existing panamax vessels was

3,600 TEUs while the panamax vessels on order have an average TEU capacity of 3,800 TEUs. Order book activity indicates that panamax vessel construction will continue resulting in an increasingly larger panamax fleet. The number of panamax vessels is increasing rapidly and has grown from 8 vessels in 1980 to 207 vessels in 1995. The orderbook currently totals 61 vessels with a total capacity of 234,000 TEUs, representing 31 percent of the fleet in TEU terms (Table 24).

Table 24. Panamax Fleet Statistical Summary

	Existing Fleet Age Range (Years)							Orderbook (Delivery)	
Item	**≥ 25**	**20 – 24**	**15 - 19**	**10 - 14**	**5 - 9**	**0 - 4**	**TOTALS**	**1996**	**1997 +**
Total No.	----	8	2	21	65	111	207	21	39
Total TEU	----	24,639	6,131	79,508	225,279	418,396	753,953	79,250	150,263
Total Dwt	----	380,023	98,992	1,126,027	3,315,944	5,763,134	10,684,120	1,014,007	2,042,250
Av. Size TEU	----	3,080	3,066	3,786	3,466	3,769	3,642	3,774	3,853
Av. Size Dwt	----	47,503	49,496	53,620	51,015	51,920	51,614	48,286	52,365
percent of Flt No.	----	3.9	1	10.1	31.4	53.6	100	10.1	18.8
percent of Flt TEU	----	3.3	0.8	10.5	29.9	55.5	100	10.5	19.9
Av. LOA m.	----	288.7	258.6	275.1	271.7	272.8	273.2		
Av. Beam m.	----	32.3	32.3	32.2	32.3	32.3	32.3		
Av. Draft m.	----	12.9	13	12.5	12.4	12.5	12.5		
Av. Speed	----	23.1	20.7	20.4	21.8	23	22.3		

Source: Clarkson Containership Register

The sub-panamax fleet as defined by Clarkson includes all container ships with a 2,000 – 2,999 TEU capacity. The sub-panamax growth appears to be peaking. There is an actual decrease in the number of newer vessels. There are 67 vessels 5-9 years old and 64 vessels 0-4 years old. Contrast that with the panamax fleet where 65 vessels are 5-9 years old and 111 vessels are 0-4 years old. The sub-panamax fleet will continue to be an important vessel for smaller subroutes, but the number of these ships appears to have leveled off as compared to the panamax and post-panamax vessels. The average design draft for sub-panamax vessel is about 3.5 feet below the target draft of 36 feet for container movements on the Columbia River, and are not constrained by the 40-foot channel depth (Table 24).

Figures 8 and 9 show the rapid growth of deliveries of all container ships in general, but also the large increase in post-panamax deliveries. In 1996, the post-panamax deliveries will make up 29 percent of the total capacity delivered. The orderbook data shows that the predominant carrying capacity is being built in the panamax and post-panamax container ships. The orderbook shows that a 168 percent increase in the current post-panamax fleet will result from the new building efforts and a 30 percent increase in the panamax fleet. Since 99 percent of Portland's fleet is sub-panamax or larger, it can be expected Portland will see some of these new vessels or the vessels that are displaced by the new vessels.

Table 25. Sub-Panamax Fleet Statistical Summary

Data Item	Existing Fleet Age Range (Years)							Orderbook (Delivery)	
	≥ 25	**20 - 24**	**15 - 19**	**10 – 14**	**5 - 9**	**0 - 4**	**TOTALS**	**1996**	**1997 +**
Total No.	1	25	58	62	67	64	277	31	31
	2,361	61,109	144,249	150,529	172,464	163,625	694,337	76,804	73,590
Total Dwt	31,303	986,033	2,237,750	2,412,724	2,722,357	2,621,091	11,011,258	1,088,610	1,007,440
Av. Size TEU	2,361	2,444	2,487	2,428	2,574	2,557	2,507	2,478	2,374
Av. Size Dwt	31,303	39,441	38,582	38,915	40,632	40,955	39,752	35,116	32,498
percent of Flt No.	0.4	9.0	20.9	22.4	24.2	23.1	100.0	11.2	11.2
percent of Flt TEU	0.3	8.8	20.8	21.7	24.8	23.6	100.0	11.1	10.6
Av. LOA m.	247.6	266.5	249.2	224.9	233.5	224.6	236.1		
Av. Beam m.	27.5	31.6	31.5	32.2	32	32	31.9		
Av. Draft m.	11.1	12	11.5	11.6	11.7	11.9	11.7		
Av. Speed	-	21.6	21.2	20.1	21	20.5	20.8		

Source: Clarkson Containership Register

Figure 8. Containership Deliveries

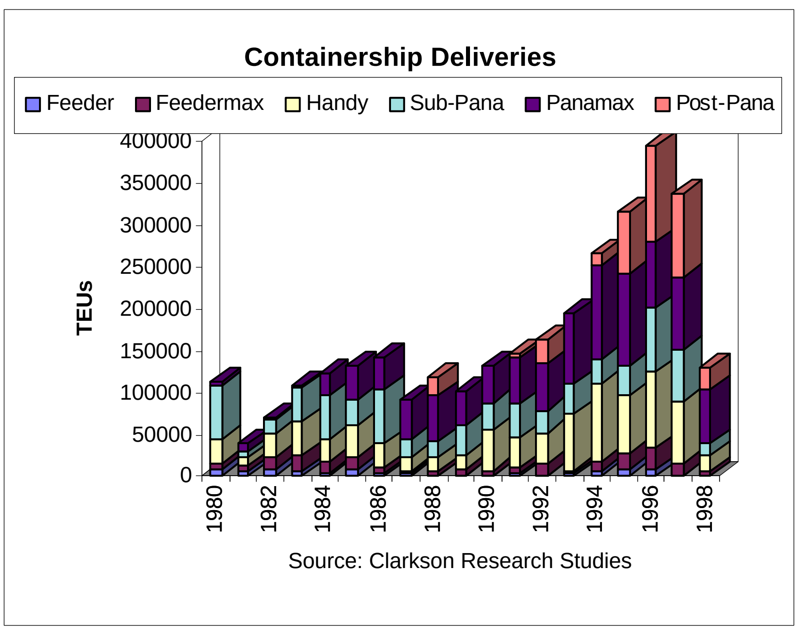
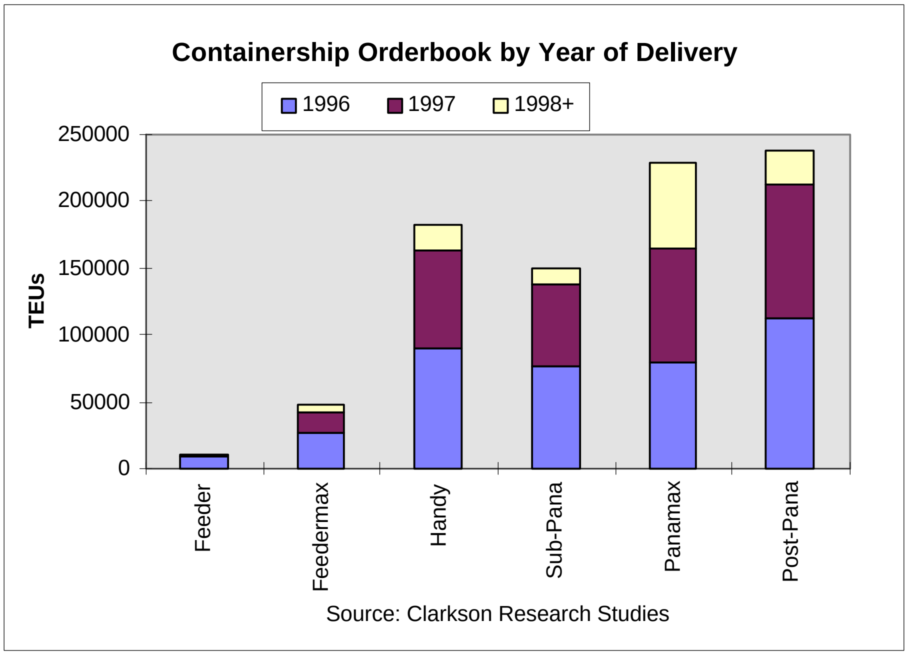


Figure 9. Containership Orderbook by Year of Delivery



6.1.10. The World Fleet - Market Interviews

The Port surveyed the major shipping lines serving the transpacific trade. Responses from the head offices of Evergreen, APL/OAK, Yangming, OOCL, and Mitsui OSK were received. The survey centered on the new building plans of these lines for the transpacific fleet. Currently, the transpacific fleet is made of 83 percent panamax vessels (defined by the port as = or < 4,400 TEU), 17 percent post-panamax (defined as = or > 4,400 but < 5,500 TEU), and 0 percent (= or > 5,500 TEU). The Port of Portland asked what the likely make up of the transpacific fleet would be in 2010. Three firms ventured estimates as shown in Table 25. What is evident from the table is the expected dramatic increase in post-panamax vessel serving the transpacific trade. All forecasts predict that the percentage of traffic moving on panamax vessels will decrease by at least 50 percent, while the percentage of traffic moving on post-panamax vessels is expected to nearly triple.

Table 26. Industry Container Fleet Expectations

TEU Capacity	1995	2010		
		APL/OAK	OOCL	Yangming
= or < 4,400 (panamax)	83%	15%	52%	40%
= or > 4,400, but < 5,000 (post- panamax)	17%	60%	40%	40%
= or > 5,500 (post-panamax)	0%	25%	8%	20%

Three of the firms surveyed have constructed or are constructing vessels with over a 4,400 TEU capacity to serve the transpacific trade. Design drafts for these vessels range from 43 to 47 feet. Some of the vessels under construction are expected to reach their design drafts during westbound transits. Others at their maximum will operate at one meter below the design draft. In response to the depth needed to accommodate the current fleet, 40 to 50 feet is required. The depths vary by order of call and eastbound versus westbound. Traffic westbound requires about a meter more depth than eastbound traffic. This is because of the relatively heavy cargo westbound. Based on these survey results, current container ships servicing the transpacific trade are constrained if Portland is the last port of call. For new container ships, the problem becomes even more dramatic.

Table 27. Percentage of Portland & World Fleet by TEU Capacity

Shipping Line	TEU Capacity	Design Draft	Fully Loaded Westbound - Draft
MOL	2,852	39.2	37.1
Evergreen	5,364	42.8	42.8
APL/OAK	4,800	47.2	47.2
Yang Ming	3,725	38.7	38.7
OOCL	4,960	47.2	43.8

6.1.11. The Portland Fleet

The Portland container fleet is similar to the world fleet except that the smaller vessels in the world fleet generally do not serve Portland (Table 27). This can be seen by comparing the 1993 Portland containership fleet (for which there is data) with the 1996 world containership fleet. Handy (1,000 - 1,999 TEU) accounts for 30 percent of the world fleet TEU, while only 1 percent of the Portland fleet is handy in terms of TEU. Sub-panamax (2,000 -2,999 TEU) makes up 25 percent of the world fleet in TEUs. The Portland fleet is made up of 61 percent sub-panamax vessels. The world fleet is 27 percent panamax (3,000 TEU with Panama Canal dimensions) in terms of TEU and the Portland fleet is 32 percent panamax. Four percent of the TEU capacity for the world fleet is in post-panamax (+4,000 TEU, exceeding Panama dimensions), while 6 percent of the Portland fleet TEU capacity is in post-panamax vessels. Portland has a large share of its TEU capacity in large capacity vessels as compared to the world fleet.

Table 28. Percentage of Portland and World Fleet by TEU Capacity

Category	Portland Fleet	World Fleet
Less Than 1,000 TEU	0%	14%
Handy (1,000 - 1,999 TEU)	1%	30%
Sub-Panamax (2,000 - 2,999 TEU)	61%	25%
Panamax (3,000 TEU w/ Panama Canal dimensions	32%	27%
Post-Panamax (+4,000 TEU, exceeding Panama dimensions	6%	4%
TOTAL	100%	100%

Several of the container lines calling Portland are shifting to larger vessels. Evergreen plans on deploying its new post-panamax 4,900 TEU vessels through Portland. These vessels will draft 42 feet. The deployment of the larger Evergreen vessels is especially significant given that Evergreen accounts for over 40 percent of the Port of Portland container traffic. Currently Evergreen uses 3,400 TEU vessels and these vessels have a design draft of 39 feet. Hyundai, a relatively new line for Portland, plans on replacing its 2,000 TEU vessels with 3,000 TEU vessels that will have design drafts of 40 feet. Representatives of Hyundai expect to replace these 3,000 TEU vessels with vessels drafting 42 feet before 2004, stating that the 2,000 TEU vessels only called the West Coast for four years before they were replaced. Also NYK expects to replace its container ships drafting 39 feet with container ships drafting 43 feet before 2004. These new vessel deployments are a strong indication of the move to larger container ships. The average per-vessel carrying capacity of the Portland container fleet has grown by 300 percent over the last ten years (1985-1995). It is apparent that there is a strong move underway for larger capacity container ships at Portland.

Given that over 95 percent of the container tonnage was carried on vessels with design drafts over 39 feet and the target draft is 36feet for container ships, one of the key issues with the fleet forecast is the extent the fleet would take advantage of a deeper channel. The historical operating practice as shown in Table 29 and Table 29 for the last three years is the basis for expected use of the channel both with and without the project. The tables are broken out by last port of call and middle port of call (Portland has no first port of call service at this time) to identify any different design or operating practices and facilitate the calculation of benefits. It appears that the fleet is similar for vessels calling Portland as a middle or last port of call. The typical maximum operating draft is the maximum draft generally observed for each design draft. The typical average operating draft is generally the observed average draft for each design draft.

For departure drafts, it appears that the vessels calling Portland as a last port of call load deeper. In 1995, 99 percent of the container vessels with departure drafts above 34 feet call Portland as their last port. This appears to be especially pronounced in 1995 in the upper design drafts where the maximum departure draft differs by as much as 4 feet between vessels calling Portland as a last versus a middle port of call. Another factor that is apparent in these tables is the growth in average departure drafts over the last three years for last port of call vessels. The average departure draft in 1993 for container vessels that were last port of call was 33 feet for vessels that were middle port of call the average departure draft was 31 feet. In 1995, the average departure draft was 36 feet for last port of call container vessels. For container vessels that were middle port of call the average departure draft was 29 feet. The average departure draft for last port of call vessels with design drafts of 39 feet increases from 33 feet in 1993 to 36 feet in 1995. This is significant given the large number of vessels of this size. This movement is indicative of containership lines attempting to maximize the efficiency of these larger vessels.

Table 29. Columbia River Container Fleets 1993-1995, Last Port of Call

	1993			1994			1995		
Design Draft (feet)	**Vessel Calls**	**Typical Max Draft**	**Typical Ave Draft**	**Vessel Calls**	**Typical Max Draft**	**Typical Ave Draft**	**Vessel Calls**	**Typical Max Draft**	**Typical Ave Draft**
31									
32									
33									
34									
35									
36	3	32	32	4	37	35	4	37	35
37									
38				2	35	33	4	36	35
39	130	38	33	96	38	35	114	39	36
40	11	36	33	10	36	34	10	36	33
41				6	37	35			
42	19	37	35	59	40	37	21	39	39
Total	163			177			153		

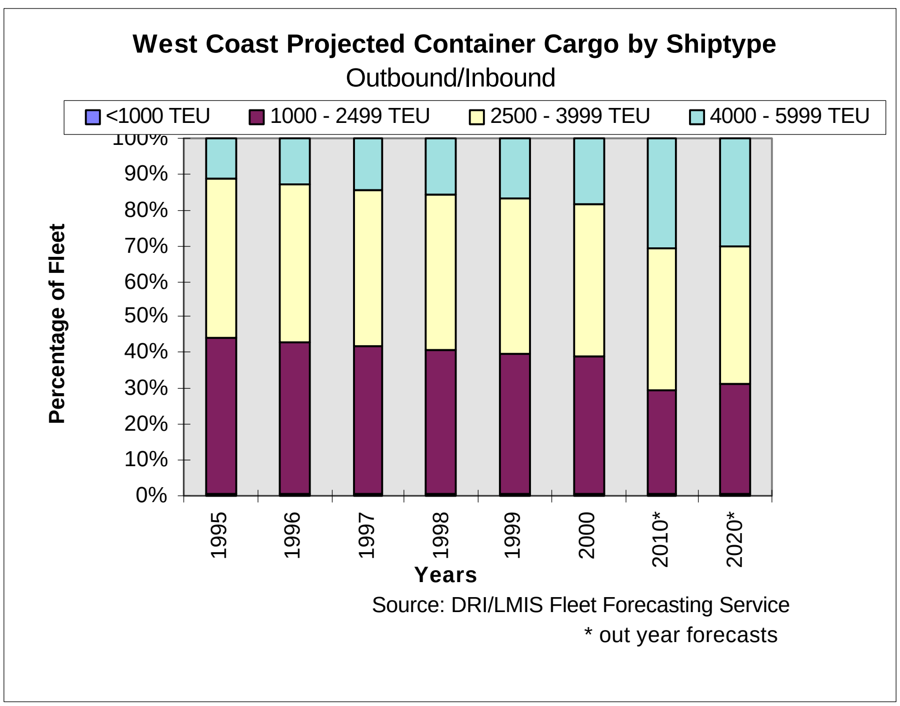
Table 30. Columbia River Container Fleets 1993-1995, Middle Port of Call

	1993			1994			1995		
Design Draft (feet)	**Vessel Calls**	**Typical Max Draft**	**Typical Ave Draft**	**Vessel Calls**	**Typical Max Draft**	**Typical Ave Draft**	**Vessel Calls**	**Typical Max Draft**	**Typical Ave Draft**
31	2	29	28	4	27	26	4	28	28
32									
33									
34	2	29	29						
35	1	34	34						
36				14	32	27	16	30	27
37				15	31	27	20	35	28
38	2	27	27	6	32	28	9	32	29
39	65	38	31	68	34	30	61	35	30
40	1	32	32	5	31	27			
41									
42	9	36	34	11	39	37			
Total	82			123			110		

6.1.12. DRI West Coast Fleet Forecast

Figure 10 shows the forecast by the DRI/LMIS Fleet Forecasting Service for the 1st quarter of 1995 for the West Coast based on 1993 data. Portland makes up about 3 percent of the West Coast container market. The figure shows a projected increase in cargo carried by larger container ships. DRI forecasts that ships with TEU capacities between 4,000 and 5,999 TEUs will grow from carrying 11 percent of the West Coast container tonnage in 1995 to 30 percent by 2020. The average design draft of these vessels is 43 feet for the world fleet based on data in *Strong Grain Market Boosts Panamaxes*, in *Fairplay*, April 1996 (page 43). The vessels that carry between 2,500 - 3,999 TEUs will continue to move the majority of container traffic. In 1995 this ship type is expected to carry 44 percent of container traffic. This is expect to decrease slowly over time to 39 percent in 2020, the result of more tonnage moving on larger vessels. For the world fleet, these vessels have an average design draft of 40 feet based on Fairplay data. The remainder of the container traffic (43 percent) moves on vessels with TEU capacities ranging from 1000-2500 TEUs. This is expected to drop to 31 percent by 2020. These vessels have an average design draft of 35 feet based on Fairplay data. It is apparent that West Coast container traffic is projected to move to deeper draft vessels in the future. Portland's fleet will be part of this trend.

Figure 10



In 1993, 34 percent of the outbound container traffic (loaded at Portland and on board) moved on container vessels with TEU capacities between 1,000-2,499 TEUs. Sixty one percent of the outbound container traffic departed on vessels with TEU capacities between 2,500-3,999. The other 4 percent departed on vessels with TEU capacities between 4,000-5,999 TEUs. If the Portland fleet composition changed at the same rate as DRI projected for the West Coast, in 2020 about 27 percent of the container traffic would move on vessels with TEU capacities below 2,500 TEUs. Traffic on 2,500-3,999 TEU vessels would decrease to 59 percent while container traffic would increase to 14 percent for container vessels with 4,000-5,999 TEU capacity.

The DRI forecast likely understates the possible growth in tonnage moved on larger vessels because it is based on 1993 data. Review comments from the Port of Portland and the Institute for Water Resources (IWR). In 1994 and 1995, there has been an incredible increase in the construction and order of post-panamax vessels worldwide. In the 1995 Clarkson Containership Register a total of 28 post-panamax vessels were to be delivered in 1996 and beyond. A year later in the 1996 Clarkson Containership Register a total of 46 post-panamax vessels were to be delivered in 1996 and beyond.

Using the growth rates from the DRI forecast, 14 percent of Portland tonnage is projected to move on vessels with a TEU capacity of 4,000-5,999 in 2020. Based on preliminary 1995 data from the Port of Portland 13 percent is already moving on that size vessel. Although the DRI forecast likely understates the fleet projections, it does show the trend toward increasing use of larger vessels. Because of the shortcomings of this DRI forecast, it is not a key factor in the projected Columbia River container fleet.

6.1.13. 1993 Columbia River Fleet (Baseline)

The 1993 fleet serves as the baseline for the fleet forecast. The Port of Portland provided detailed information on this fleet. Table 30 outlines the pertinent data. The most common design draft in the world fleet is 39 feet. In 1993, this was also the case for the fleet calling Portland. Over 80 percent of the container ship calls were vessels with design drafts of 39 feet. Therefore, the near-term forecast is heavily weighted toward vessels of design drafts of 39 feet. Over time, the weighting toward vessels with design drafts of 39 feet decreases.

In 1993, tonnage was concentrated on vessels with design drafts of 39 to 42 feet. This indicates the likely vessels that tonnage will move on in the future. It is highly unlikely that the number of container vessels with design drafts below 39 feet will increase on the Columbia River given the history of the fleet and new building trends. The maximum design draft of the 1993 fleet was 42 feet or 6 feet above the target draft. The target draft with a 43-foot channel would be 39 feet for most vessels.

To focus the analysis the fleet has been broken into container ships that were last port of call and middle port of call. The design drafts of the two categories of vessels are fairly similar, and it is assumed that there is no difference in the type of vessels calling as a middle or last port of call. However, there are differences in departure drafts. The average and maximum departure draft is deeper for last port of call vessels as would be expected.

Many of the container vessels in 1993 departed below the target draft. No doubt some of this is the result of draft restrictions associated with the channel. Still, the vessels with design drafts of 39 to 40 feet often departed significantly below the 36-foot unconstrained target draft in 1993. In 1994 and 1995, container ships are leaving closer to the target draft and their design drafts. In 1995, 85 percent of the last port of call vessels left at a departure draft of 35 feet or greater as compared to 29 percent in 1993. The more current 1994 and 1995 data are believed to be more indicative of future departure drafts.

Table 31. Columbia River Without-Project Container Fleets - 2004

Last Port of Call – 1993 (Base Condition)				**Mid Port of Call - 1993 (Base Condition)**			
Design Draft (feet)	**Typical Maximum Draft**	**Typical Average Draft**	**Percent of Tonnage**	**Design Draft (feet)**	**Typical Maximum Draft**	**Typical Average Draft**	**Percent of Tonnage**
36	32	32	1.07	31	29	28	0.44
37				32			
38				33			
39	38	33	55.22	34	29	29	0.91
40	36	33	4.43	35	34	34	0.55
41				36			
42	37	35	9.59	37			
				38	27	27	0.33
				39	38	31	22.73
				40	32	32	0.40
				41			
				42	36	34	4.33

6.1.14. Fleet Forecast 2004 (Without-Project Condition)

The fleet projections show the expected composition of the fleet by design draft, average departure draft, and percent of tons carried. To simplify the display and discussion of the fleet projections average departure drafts are used. The distributions around these averages are discussed in the benefit analysis. The projected departure drafts are based mainly on historical operating practices. Vessels that have not been constrained by the channel are not projected to benefit from the channel deepening. The percentage of tons carried by each design draft are projected mainly on historical trends, vessel deployment plans, and interviews of shipping industry officials.

Ninety seven percent of container tonnage in 1993 departed on vessels with design drafts of 39 feet or more. Almost 70 percent of the tonnage was on last port of call vessels with design drafts over 39 feet. Because some major carriers are planning to deploy vessels with design drafts of 41 to 43 feet within the 1996-1998 time frame, in the without-project condition (2004), it is anticipated that the majority of container tonnage will move on vessels with design drafts of 39 to 43 feet. Three of the four major lines expect to bring vessels drafting +42 feet by 2004. Evergreen will start deploying their post-panamax vessels drafting 42 feet during the summer of 1996. NYK expects to start deploying their post-panamax vessels through Portland in 1997. These vessels will draft 42.9 feet. Hyundai will bring its 3,000 TEU vessels drafting 39 feet in October 1996 and expect to replace these container ships with 4,400 TEU vessels drafting 42 feet before 2004. Given this information, the 2004 forecast assumes that tonnage will shift from vessels with design drafts of 39 feet in 1993 to vessels with design drafts between 39 and 43 feet in 2004. It is forecasted that tonnage will drop from 78 percent on vessels with design drafts of 39 feet in 1993 to 34 percent in 2004 as more tonnage is shifted to deeper draft vessels. This is primarily the result of the industry building and deploying larger vessels on the transpacific routes. In 1995, NYK, Evergreen, and Hyundai moved over 50 percent of the outbound tonnage. All of these carriers are expected to have vessels drafting over 42 feet by 2004. Given that it is likely that carriers, ports of call, market shares, and vessel deployments are likely to change before 2004, an estimate of 40 percent of tonnage moving on vessels with design drafts of 42 feet or greater is used. Tonnage carried on vessels with design drafts of 40 feet is expected to increase from 5 percent in 1993 to 13 percent in 2004. This is supported by the expectation that more vessels with 40-foot design drafts will become part of the fleet calling Portland by 2004.

The forecast also projects that tonnage traveling on vessels with design drafts of 42 feet will increase from 14 percent in 1993 to 24 percent in 2004. This is supported by the fact that Evergreen is expected to deploy their 4,900 TEU vessels drafting 42 feet in 1996. In 1994, Evergreen and NYK routed vessels with design drafts of 42 feet through Portland. This increased the number of vessels with design drafts of 42 feet by 100 percent from 1993 to 1994. In 1995, this was reduced as NYK deployed it vessels on a route excluding Portland. Given 1994 though Portland has shown its ability to attract a similar volume of cargo on vessels with design drafts of 42 feet as is projected in 2004.

For this analysis, it is assumed that the design drafts will not exceed 45 feet. This is reasonable given the physical constraints of the channel in both the with- and without-project condition, as well as the industry aversion to light-loading, and the relative small number of container vessels built with design drafts in excess of 45 feet.

Projected departure drafts are based on historical practices and trends. Last port of call vessels carry 70 percent of the departing tonnage. These vessels have historically departed at deeper drafts and are expected to continue in the future. Last port of call vessels with design drafts of 36 to 38 feet will depart at an average of 35 feet in the without-project condition. There have been few of these vessels in the recent past (1993-1995) and few are projected in the future. The vessels that have called in 1994 with design drafts of 36 feet departed at an average of 35 feet. Last port of call vessels with design drafts of 39 feet will depart at an average of 36 feet increasing to 37 feet for vessels with design drafts of 41 feet. Historically, the average departure drafts of 95 percent of the vessels has ranged from 32 to 40 feet. The trend over the three-year history appears to be toward deeper departure drafts. For every design draft, average departure drafts are deeper in 1995 than 1993. In addition, the majority of vessels have been at a design draft of 39 feet and the most recent data shows an average departure draft of 36 feet. Last port of call vessels with design drafts of 42 feet will depart at an average of 38 feet increasing to 39 feet for vessels with design drafts of 45 feet. The majority of container vessels target 36 feet as their departure draft. This was confirmed by the pilots given the current channel depth. However, Evergreen in the last two years has departed at drafts of 36 to 40 feet. Because of different operating practices Evergreen is willing to incur the delay expenses to leave at a deeper departure draft. So far they are the only carrier to do this to any significant degree. In the future, it is expected that Evergreen will continue this practice and other lines with larger vessels may also resort to this practice. Evergreen is not the only company to bring vessels with design drafts of 42 to 45 feet to Portland. In the future, it is anticipated there will be mixture of target drafts for these larger vessels leading to an average departure draft of 38 to 39 feet. In 1994, the average departure draft was 37 feet for vessels with design drafts of 42 feet. In 1995, the average departure draft was 39 feet for vessels with design drafts of 42 feet.

The average departure draft for middle port of call vessels with design drafts of 36 feet would be 27 feet as it was in 1993 -1995. Middle port of call vessels with design drafts of 37 and 38 feet will have departure drafts of 28 and 29 feet as they did in 1995. For middle port of call vessels with design drafts of 39 to 40 feet, the departure draft is 31 feet in the without-project condition. Historically, most middle port of call vessels have a design draft of 39 feet and the average departure draft has been 31 and 30 feet in 1993 and 1995, respectively. The departure draft for vessels with design drafts of 41 and 42 feet are 33 and 35 feet, respectively. In 1993 and 1994, Evergreen called Portland as a middle port of call with vessels of design drafts of 42 feet. In 1993, these vessels called Portland as middle port of call nine times and had an average departure draft of 34 feet with a maximum departure draft of 36 feet. In 1994, these same vessels called Portland as a middle port of call eleven times and had an average departure draft of 37 feet with a maximum departure draft of 39 feet. Based on this information, it is assumed that vessels with design drafts of 42 feet will have departure drafts on average of 36 feet. There has been only one vessel call with a design draft greater than 42 feet, and it departed at a draft of 28 feet as a middle port of call. However, when vessels of this size do call, it is anticipated that they will depart at the target draft of 36 feet given the trend in the departure drafts of the smaller vessels. Table 32 shows the projected fleet in 2004.

Table 32. Columbia River Without-Project Container Fleets - 2004

Last Port of Call 2004 Without-Project				**Middle Port of Call 2004 Without-Project**			
Design Draft (feet)	**Typical Maximum Draft**	**Typical Average Draft**	**Percent of Tonnage**	**Design Draft (feet)**	**Typical Maximum Draft**	**Typical Average Draft**	**Percent of Tonnage**
35				35			
36	36	35	0.70	36	28	27	0.30
37	37	35	0.70	37	29	28	0.30
38	38	35	0.70	38	36	29	0.30
39	39	36	23.80	39	37	31	10.20
40	40	36	9.10	40	38	31	3.90
41	40	37	7.00	41	39	33	3.00
42	40	38	16.80	42	39	36	7.20
43	40	38	7.70	43	39	36	3.30
44	40	39	2.10	44	39	36	0.90
45	40	39	1.40	45	39	36	0.60

6.1.15. Fleet Forecast 2004 (With 43-foot Project)

In the with-project condition in 2004, the container fleet is projected to look similar to the fleet without the project in terms of design drafts. However, departure drafts will be deeper as vessels formerly constrained by the without-project depths would be able to more fully utilize their capacity. The drafts and dimensions of the containership fleet serving Portland is driven by the 1st port of call destinations on the West Coast. These are primarily ports in the Puget Sound as well as California ports. A variety of factors drive the demand for larger ships. Based on interviews with the local carriers, competition, port facilities, and traffic volume are important factors. Portland is the tail on the dog and container lines are not likely to construct or redeploy vessels as the result of deepening at Portland. In addition many of the carriers believed that 3 feet deepening is not enough. Even with the deepening, the target draft would be 39 feet which is still 3 feet below the average design draft for a panamax container vessel. Currently design drafts of vessels calling Portland are as much as 6 feet above the target draft. With a channel deepening of 3 feet, the maximum design draft vessel (45 feet) will again be 6 feet above the target draft. For these reasons the design drafts are assumed to be the same in the with- and without-project conditions.

As discussed above, the fleet in the with- and without-project conditions are expected to be the same. The same amount of tonnage will leave on vessels of the same design draft with and without a project. The departure drafts will largely be different however. In the with-project condition, for last port of call vessels with design drafts of 37 feet and below the average departure draft will be 35 feet. This is the same departure draft as in the without-project condition. These vessels have historically not taken advantage of the current channel depth and will not take advantage of a deeper channel in the with-project condition. Last port of call vessels with design drafts of 38 feet will depart at an average of 36 feet in the with-project condition. This is a deeper departure draft by one foot than in the without-project condition. These vessels have excess capacity available and it is likely some of the carriers would be able to take advantage of the deeper channel increasing the average departure draft by one foot in the without-project condition. Last port of call vessels with design drafts of 39 feet will depart at an average draft of 37 feet in the with-project condition. This is one foot deeper than in the without-project condition. All vessels will not be able to take full advantage of the channel because of volume constraints on some of the vessels preventing departure at design drafts. Vessels are expected to take increasing advantage of the channel in the with-project condition up to a maximum of 3 feet (the amount of the deepening) as the design drafts of the vessels increase. Vessels with a design draft of 40 feet will depart at an average of 38 feet. Vessels with design drafts of 41 to 42 feet will depart at an average of 39 feet. Vessels with design drafts of 43 to 44 feet will depart at an average of 44 feet, and vessels with design drafts of 45 feet will depart at an average of 42 feet.

For vessels that call Portland as a middle port of call departure drafts will be the same in the with- and without-project condition for all vessels with the exception of the vessels with design drafts of 42 feet and above. Middle port of call vessels with design drafts below 42 feet are rarely constrained by the channel. The average departure draft of vessels with design drafts of 41 feet is expected to be only 33 feet in the without-project condition. This is 3 feet below the target draft. For middle port of call vessels with design drafts between 42 and 44 feet, departure drafts will be 1 to 2 feet deeper than in the without-project condition. These vessels will be able to take advantage of the excess capacity available and are expected to have vessels departing at the channel constraint in the without-project condition. Middle port of call vessels with design drafts of 42 feet will depart at 37 feet in the with-project condition. Middle port of call vessels with design drafts of 43 and 44 feet will depart at 38 feet in the with-project condition. Vessels with design drafts of 45 feet and Portland as a middle port of call will depart at 39 feet in the with-project condition. Table 32 shows the projected fleet in the with-project condition in 2004.

6.1.16. Fleet Forecast 2014 (With and Without 43-foot Project)

This section describes both the with- and without-project fleet forecast for 2014 (Tables 33 and 34). For the 2014 projection, tonnage is expected to drop most rapidly from vessels with design drafts of 39 feet. For the 2004 forecast, 34 percent of the tonnage was projected to move on vessels with design drafts of 39 feet. By 2014, however, this is expected to drop to 22 percent. This is a continuation of the trend seen in the 2004 forecast but at a slower pace. This appears reasonable as no significant tonnage currently moves at design drafts below 39 feet. The tonnage will slowly shift to the vessels with design drafts above 39 feet. Two major factors will influence the inclination toward these vessels with deeper design drafts. The first is the economies of scale that result from these larger vessels. This is supported by the historical trends in containership sizes on the Columbia and in the world. This is also consistent with industry forecasts. The second factor is the large construction boom in container vessels coupled with deployment decisions demonstrating that larger vessels are viable and needed to be competitive. Almost all carriers are constructing larger vessels.

Table 33. Columbia River With-Project Container Fleets - 2004

Last Port of Call 2004 With 43-foot Channel				**Middle Port of Call 2004 With 43-foot Channel**			
Design Draft (feet)	**Typical Maximum Draft**	**Typical Average Draft**	**Percent of Tonnage**	**Design Draft (feet)**	**Typical Maximum Draft**	**Typical Average Draft**	**Percent of Tonnage**
35							
36	36	35	0.70	36	28	27	0.30
37	37	35	0.70	37	29	28	0.30
38	38	36	0.70	38	36	29	0.30
39	39	37	23.80	39	37	31	10.20
40	40	38	9.10	40	38	31	3.90
41	41	39	7.00	41	39	34	3.00
42	42	39	16.80	42	39	37	7.20
43	43	40	7.70	43	40	38	3.30
44	43	42	2.10	44	40	38	0.90
45	43	42	1.40	45	40	39	0.60

The departure drafts remain unchanged from the forecast in 2004. Vessels will have taken maximum possible advantage of the channel at the completion of construction in 2004. Because a change in the fleet is not expected as a result of the channel deepening, vessels will not have to be redeployed to take advantage of the deeper channel. Container vessels already calling will move quickly to take advantage of the economies of scale resulting from the deeper channel. History has shown that the container industry is very dynamic and moves quickly to ensure the maximization of profit.

Table 34. Columbia River Without-Project Container Fleets - 2014

Last Port of Call 2014 Without-Project				**Middle Port of Call 2014 Without-Project**			
Design Draft (feet)	**Typical Maximum Draft**	**Typical Average Draft**	**Percent of Tonnage**	**Design Draft (feet)**	**Typical Maximum Draft**	**Typical Average Draft**	**Percent of Tonnage**
36				36			
37	37	35	0.70	37	29	28	0.30
38	38	35	0.70	38	36	29	0.30
39	39	36	15.40	39	37	31	6.60
40	40	36	11.90	40	38	31	5.10
41	40	37	9.10	41	39	33	3.90
42	40	38	18.20	42	39	36	7.80
43	40	38	9.10	43	39	36	3.90
44	40	39	2.80	44	39	36	1.20
45	40	39	2.10	45	39	36	0.90

Table 35. Columbia River With-Project Container Fleets - 2014

Last Port of Call 2014 With 43 feet Channel				**Middle Port of Call 2014 With 43 feet Channel**			
Design Draft (feet)	**Typical Maximum Draft**	**Typical Average Draft**	**Percent of Tonnage**	**Design Draft (feet)**	**Typical Maximum Draft**	**Typical Average Draft**	**Percent of Tonnage**
36				36			
37	37	35	0.70	37	29	28	0.30
38	38	36	0.70	38	36	29	0.30
39	39	37	15.40	39	37	31	6.60
40	40	38	11.90	40	38	31	5.10
41	41	39	9.10	41	39	34	3.90
42	42	39	18.20	42	39	37	7.80
43	43	40	9.10	43	40	38	3.90
44	43	42	2.80	44	40	38	1.20
45	43	42	2.10	45	40	39	0.90

6.1.17. Fleet Forecast 2024 (With and Without 43-foot Project)

This section describes both the with- and without-project fleet forecast for 2024 (Tables 35 and 36). For the 2024 projection, tonnage is again expected to drop most rapidly from vessels with design drafts of 39 feet. In the 2014 projection, vessels with design drafts of 39 feet carried 22 percent of the container tonnage. For the 2024 projection, tonnage is expected to drop to 13 percent on vessels with design drafts of 39 feet. This is primarily the result of carriers moving to larger and more economically efficient vessels. A good share of the tonnage will now move on vessels with design drafts of 40 feet. The tonnage on vessels with design drafts of 40 feet will increase by 3 percent from 17 percent in 2014 to 20 percent in 2024. In addition, the tonnage lost by the smaller vessels will go to vessels with design drafts of between 41 and 44 feet. Tonnage on vessels with design drafts of 42 feet increase slightly faster than tonnage on vessels with design drafts of 41 and 43 feet. This is because currently, there are very few vessels with design drafts of 41 and 43 feet. Departure drafts will stay consistent with earlier forecasts.

6.1.18. Fleet Forecast 2034-2054 (With and Without 43-foot Project)

This section describes both the with- and without-project fleet forecast for 2034 – 2054 (Tables 37 and 38). As agreed by the sponsor and the Corps, the fleet is held constant after 2024. This is the result of the uncertainty regarding projecting the fleet for 30 years in the future. Departure drafts will stay consistent with earlier forecasts.

Table 36. 2024 Without-Project Container Fleets

Last Port of Call 2024 Without-Project				Middle Port of Call 2024 Without-Project			
Design Draft (feet)	Typical Maximum Draft	Typical Average Draft	Percent of Tonnage	Design Draft (feet)	Typical Maximum Draft	Typical Average Draft	Percent of Tonnage
36				36			
37				37			
38	38	35	0.70	38	36	29	0.30
39	39	36	9.10	39	37	31	3.90
40	40	36	14.00	40	38	31	6.00
41	40	37	10.50	41	39	33	4.50
42	40	38	18.90	42	39	36	8.10
43	40	38	10.50	43	39	36	4.50
44	40	39	3.50	44	39	36	1.50
45	40	39	2.80	45	39	36	1.20

Table 37. 2024 43-Foot Channel Container Fleets

Last Port of Call 2024 With 43-foot Channel				Middle Port of Call 2024 With 43-foot Channel			
Design Draft (feet)	Typical Maximum Draft	Typical Average Draft	Percent of Tonnage	Design Draft (feet)	Typical Maximum Draft	Typical Average Draft	Percent of Tonnage
36				36			
37				37			
38	38	37	0.70	38	36	29	0.30
39	39	38	9.10	39	37	31	3.90
40	40	38	14.00	40	38	31	6.00
41	41	39	10.50	41	39	34	4.50
42	42	39	18.90	42	40	37	8.10
43	43	40	10.50	43	40	38	4.50
44	43	42	3.50	44	40	38	1.50
45	43	42	2.80	45	40	39	1.20

Table 38. Container Fleet Forecasts 2034-2054, Without-Project Condition

Last Port of Call 2034–2054 Without-Project				Middle Port of Call 2034-2054 Without-Project			
Design Draft (feet)	**Typical Maximum Draft**	**Typical Average Draft**	**Percent of Tonnage**	**Design Draft (feet)**	**Typical Maximum Draft**	**Typical Average Draft**	**Percent of Tonnage**
37				37			
38	38	35	0.70	38	36	29	0.30
39	39	36	5.60	39	37	31	2.40
40	40	36	10.50	40	38	31	4.50
41	40	37	11.90	41	39	33	5.10
42	40	38	21.00	42	39	36	9.00
43	40	38	11.90	43	39	36	5.10
44	40	39	4.90	44	39	36	2.10
45	40	39	3.50	45	39	36	1.50

Table 39. Container Fleet Forecasts 2034-2054, With-Project Condition

Last Port of Call 2034 – 2054 With 43-foot Channel				Middle Port of Call 2034 - 2054 With 43-foot Channel			
Design Draft (feet)	**Typical Maximum Draft**	**Typical Average Draft**	**Percent of Tonnage**	**Design Draft (feet)**	**Typical Maximum Draft**	**Typical Average Draft**	**Percent of Tonnage**
37				37			
38	38	36	0.70	38	36	29	0.30
39	39	37	5.60	39	37	31	2.40
40	40	38	10.50	40	38	31	4.50
41	41	39	11.90	41	39	34	5.10
42	42	39	21.00	42	40	37	9.00
43	43	40	11.90	43	40	38	5.10
44	43	42	4.90	44	40	38	2.10
45	43	42	3.50	45	41	39	1.50

Tables 40 and 41 display the projected number of container vessel trips for middle port of call container vessels over the period of analysis. Over the next 20 years, it is projected that the number of these vessel calls will almost double, although a channel deepening reduces the number of vessel calls by six percent in 2014.

Table 40. Middle Port of Call Number of Vessel Trips, 40-foot Channel

Design Draft (feet)	1995	2004	2014	2024	2034	2044	2054
31	4	-	-	-	-	-	-
36	16	3	-	-	-	-	-
37	20	3	4	-	-	-	-
38	9	3	3	5	6	8	10
39	61	63	56	45	36	47	61
40	-	25	45	72	71	92	119
41	-	15	27	42	63	82	105
42	-	27	40	55	81	106	136
43	-	12	19	30	44	58	74
44	-	3	5	9	16	21	27
45	-	2	4	7	12	15	19
Total	110	156	205	264	328	428	552

Table 41. Middle Port of Call Number of Vessel Trips, 43-foot Channel

Design Draft (feet)	1995	2004	2014	2024	2034	2044	2054
31	4	-	-	-	-	-	-
36	16	3	-	-	-	-	-
37	20	3	4	-	-	-	-
38	9	3	3	5	6	8	10
39	61	63	56	45	36	47	61
40	-	25	45	72	71	92	119
41	-	14	24	37	56	73	94
42	-	25	36	51	74	97	124
43	-	10	16	25	37	48	62
44	-	2	4	7	13	17	23
45	-	1	3	5	9	11	15
Total	110	149	193	246	301	393	507

Tables 42 and 43 display the projected number of container vessel trips for last port of call container vessels over the period of analysis. Over the next twenty years, it is projected that the number of these vessel calls will almost double, although a channel deepening reduces the number of vessel calls by twelve percent in 2014.

Table 42. Last Port of Call Number of Vessel Trips, 40-foot Channel

Design Draft (feet)	1995	2004	2014	2024	2034	2044	2054
36	4	3	-	-	-	-	-
37		3	4	-	-	-	-
38	4	3	4	5	6	8	11
39	114	81	72	57	46	60	78
40	10	30	54	85	84	109	141
41		22	39	61	90	118	152
42	21	50	74	103	151	197	254
43	-	21	34	52	78	102	131
44	-	5	9	15	27	36	46
45	-	3	6	11	19	25	32
Total	153	220	296	390	502	655	844

Table 43. Last Port of Call Number of Vessel Trips, 43-foot Channel

Design Draft (feet)	1995	2004	2014	2024	2034	2044	2054
36	4	3	-	-	-	-	-
37		3	4	-	-	-	-
38	4	2	3	4	6	8	10
39	114	75	66	52	42	55	71
40	10	27	48	75	74	97	125
41		19	34	52	77	101	130
42	21	43	65	90	131	171	221
43	-	18	29	45	67	88	113
44	-	4	7	12	22	29	37
45	-	2	5	9	15	20	25
Total	153	195	261	340	435	568	732

6.2. Bulk Carrier Fleet

In projecting a future bulk carrier fleet for the Columbia River, the world bulk fleet, draft constraints, and other operating constraints would need to be considered. Trends in the world fleet would generally be followed for the Columbia River, as allowed by various draft constraints, institutional constraints, and other market forces. For the purposes of this analysis, two major industry expert sources were used to project the trends for the Columbia bulk fleet (DRI/McGraw Hill, 1996; Drewry, 1996). Also, for each commodity and each major destination for that commodity, a fleet forecast was constructed that reflects both the trends of the world fleet and the particular characteristics of the trade route.

Of particular interest to the Columbia River fleet projection is the category of bulk carrier termed panamax. These vessels are typically 50,000 tons to 80,000 tons, and represent approximately 25 percent of the world dry bulk fleet. In the grain trades, the use of panamax vessels would likely grow to dominate world markets. While the Japanese wheat trade is institutionally restricted, most other markets would be expected to develop for use of panamax carriers. In discussing the future of bulk vessels, Drewry Shipping Consultants mentions some of the emerging markets which would be particularly important to the fleet:

> For the panamax sector of the shipping market, a good deal of attention needs to be taken of the "emerging markets" for grain as many of these have geared themselves up (or intend to do so) in terms of port facilities, cargo handling capabilities, and storage/silo capacities to accept shipments of around 50-55,000 cargo tonnes. In this respect, attention needs to focus on North Africa, the Asian Middle East, Pakistan and South Asia.

Table 44 displays a projection of outbound vessel movements from the Pacific Northwest by vessel size. Much of the cargo continues to move in vessels of the 40,000 to 80,000 deadweight tonnage (dwt) sizes, and there is a slight shift from vessels in the 20,000 to 40,000 dwt size to the 80,000 to 100,000 dwt size[6].

Table 44. US Northwest Routes, 1990-2044 Outbound Cargo Projections(in percent)

1,000s dwt	1990	1991	1992	1993	1994	1995	2000	2004	2010-2044
20 – 40	51	51	52	51	50	48	43	39	33
40 – 80	49	49	48	48	49	49	51	51	50
80 – 100	0	0	0	1	1	2	6	8	11
100 – 175	0	0	0	0	0	0	1	3	5
>175	0	0	0	0	0	0	0	0	1
Totals	100	100	100	100	100	100	100	100	100

Source: Personal Communication, DRI/McGraw Hill, 1996; numbers do not add because of rounding.

Within the 40,000 to 80,000 dwt ranges, there would be a variety of vessels in terms of size, draft, and grain carrying capacity. Of most interest is whether the vessels calling on Columbia River ports in the future would be of a deep enough draft to benefit from channel deepening. The Drewry report comments on the increasing size of panamax vessels:

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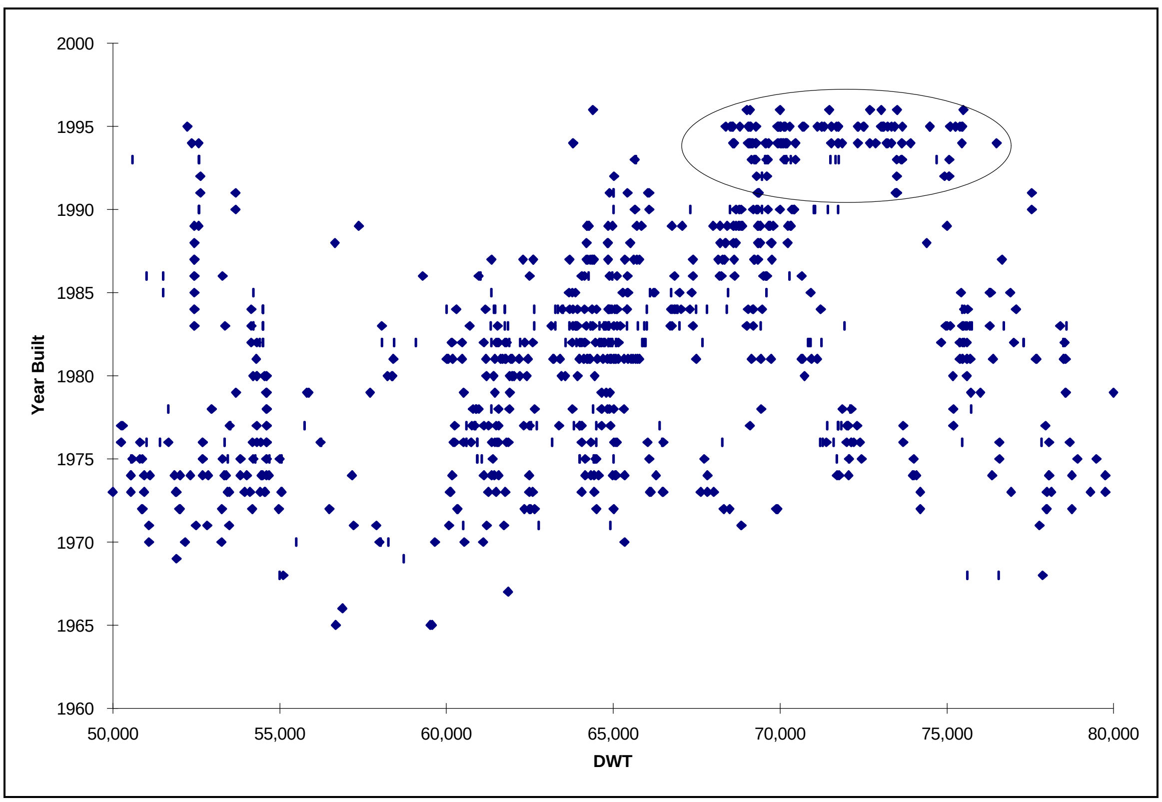
[6] As the Pacific Northwest includes the Puget Sound, some cape-size vessels (100,000 to 175,000 dwt) would likely call in the region. However, cape-size vessels would not be expected to play a significant role in the Columbia River.

Also evident is the progressive increase in the size of the 'representative' panamax dry bulk carrier. Initially, development centered around 50-55,000 tonners, which were essentially ore carrier derivatives. By the mid-1970s, the typical unit was moving around 60,000 dwt. However, the new building boom seen during the first half of the 1980s took the expectations of the typical panamax unit to 64-65,000 dwt. The late 1980s saw this figure edge toward 68-69,000 dwt while current ideas now centre around 72,000 dwt.

Figure 11 displays panamax-class builds by year and deadweight tonnage. The database shows the tendency in recent years toward the 70,000 to 75,000 dwt range. Vessels of this size typically have design drafts ranging from 43 to 45 feet. In 1993, more than 5.5 million short tons of grain left the Columbia on vessels with greater than 65,000 dwt.

The following sections provide a general description of the vessels projected to move on each trade route by commodity. For most grain trade routes, existing traffic includes vessels with design drafts greater than the current channel depth. This practice would be expected to continue in the future. For all bulk commodities, departure draft would be the only difference between the with-project fleet and the without-project fleet.

Figure 11. Panamax-Class Builds by Year and Deadweight Tonnage



Source: Clarkson's Bulk Register

6.2.1. Wheat

Columbia River wheat exports will grow from 16.4 million short tons in 2004 to 21.6 million short tons in 2054. Much of this growth will be directed to Pakistan, the Philippines, South Korea, Taiwan, Singapore, Malaysia, Indonesia, and Thailand. Table 45 displays the Columbia River wheat export projections for the period of analysis.

Table 45. Columbia River Wheat Forecast

(Millions of short tons)

Year	Japan	Other Asia	Latin America	Rapidly Developing Asia	Other	Total
2004	3.20	6.20	0.23	4.56	2.04	16.23
2014	3.13	5.41	0.26	5.43	2.00	16.23
2024	3.01	5.91	0.28	6.24	2.16	17.60
2034	2.95	8.09	0.30	7.09	2.58	21.01
2044	2.94	8.36	0.31	7.18	2.63	21.42
2054	2.94	8.36	0.31	7.18	2.63	21.42

While Japan will remain an important destination port for wheat (approximately 3 million tons per year), it is expected that Taiwan and other Asian countries will receive an increasing share of Columbia River wheat exports, as described in the commodity forecasts. Table 45 displays 1993 wheat vessel movements by departure draft and destination. Japan, South Korea, and the Philippines were the three major destinations in 1993.

6.2.1.1. Japan

Historically, the Japanese have purchased wheat in relatively small lot sizes (approximately 22,000 short tons). The reasons for these small purchases are not clear, although a number of factors have been suggested. The Japanese wheat market is highly regulated, and it is uncertain whether or not there will ever be any pressure to significantly change the current system. There are a large number of small wheat mills with limited capacity, and the current system supports the continued existence of these smaller, less efficient mills[7]. Sources in the industry have conflicting views as to the likelihood of change in the future, but, for the purposes of this study, it will be assumed that there is no significant change through the period of analysis. Approximately 3 million tons per year will be shipped to Japan in 22,000 tons lots (in appropriately sized vessels).

In 1993, the majority of Japanese wheat vessels had design drafts of approximately 33 feet. Deadweight tonnage varied between 23,000 short tons and 28,000 short tons.

[7] The Japanese also import corn from the Columbia River. Corn moves in Panamax vessels, departing the Columbia at drafts from 38 to 40 feet.

Tables 47 and 48 display the design draft and actual departure drafts for wheat vessels destined for Japan.

Given the history of Japanese movements, it is projected that the Japanese lot size will not change[8], and the wheat shipments to Japan will not benefit from a channel deepening.

Table 46. 1993 Wheat Vessel Movements by Departure Draft

Foreign Port Destination	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**
Japan			3	2	5	26	44	28	16	10	3			
Republic Of Korea				3	5	4	12	20	11	2	3		1	
Philippines							1	1	6	22	8	2		
Taiwan				1		1	1	6	9	6	4	1	1	
Yemen Arab Republic						1	3	3	1	2	2	2	1	
Uar Egypt					1	1					4	2	4	1
Saudi Arabia										2		9		
Thailand					2		3		4				1	
Ceylon (Sri Lanka)							1					3	4	1
Pakistan											4	3	2	
Hong Kong			1	1				2	2	1		1		
Bangladesh							1	1	1	2		1	1	
Malaysia	1						1	1			1		2	
China						1		1	2		1			
Rep. Of South Africa								1	2		1			1
Egypt												3	1	
Chile							1	1		1				
Kuwait							1	1	1					
New Zealand					1		1	1						
El Salvador				1					1					
Brazil								1						
Colombia			1											
Ethiopia											1			
Indonesia									1					
Jordan										1				
Kenya						1								
Sudan								1						
Russia		1												
Total	1	1	5	8	14	35	70	69	57	49	32	27	18	3

[8] The risks and uncertainty associated with this assumption are addressed in the Risk and Uncertainty Section.

Table 47. Design and Outbound Drafts, Wheat Vessels Destined for Japan, 1993.

		Outbound Draft (feet)							
Design Draft	**Average dwt**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**
31 feet	26,138	2	1						
32 feet	25,506	1	1	2	5		1	2	
33 feet	25,123			10	27	26	17	9	2
34 feet	27,123	1		2	7	7	2	2	
35 feet	30,477					3	2		1
36 feet	31,344							1	2
39 feet	33,652								1
Grand Total	25,919	4	2	14	39	36	22	14	6

Table 48. 1993 Columbia River Wheat Exports to Japan

Design Draft (feet)	Average Departure Draft	Total Tons Loaded	Number of Vessels	Percent of Tons
31	31	71,647	3	2
32	33	273,750	12	9
33	34	1,975,736	91	64
34	34	485,689	21	16
35	36	156,306	6	5
36	37	78,382	3	3
37				
38				
39	38	27,778	1	1
Totals	---	3,069,288	137	---

6.2.1.2. Rapidly Developing Asia

This region includes South Korea, Taiwan, Malaysia, Indonesia, and Thailand. As these countries experience economic growth, it is expected that wheat imports will grow. In 1995, approximately 3.45 million short tons of wheat were exported to this region from the Columbia River. It is expected that this will grow to almost 7.2 million short tons by the year 2054.

Unlike Japan, these countries do not impose institutional constraints on its lot sizes. In Southeast Asia, wheat use has grown by nearly 50 percent in the 1990s. Growing at a rate of almost 10 percent a year from 1990-1991 and 1993-1994. It is expected that as these countries experience economic growth, consumption of wheat will also grow, and economic forces will push towards larger and more efficient grain handling facilities. In 1993, vessels destined for Taiwan, Thailand, South Korea, Malaysia, Hong Kong, and Sri Lanka left at departure drafts of 39 feet or greater. As the wheat markets are still developing in these countries, often wheat shipments to these countries are constrained by destination draft or destination processing capacity. It is expected that, in the without-project condition, that shipments of wheat to these countries will gradually shift to Panamax size loads.

In a with-project condition, it is expected that that these shipments will gradually increase in size to make full use of Panamax vessels. General opinion among industry experts is that economic forces will generally lead to Panamax size vessels dominating the wheat market (with the exception of Japanese shipments).

Tables 49 and 50 display information regarding the 1993 Columbia River wheat exports to Taiwan and South Korea. While Taiwanese wheat vessels current are somewhat limited in design draft, this is primarily due to processing capacity, rather than an institutional constraint or a draft constraint[9]. Korean wheat movements generally follow a trend similar to that of Taiwanese movements. Table 51 displays 1993 wheat exports to the Rapidly Developing Asia region.

Table 49. 1993 Wheat Vessel Movements to Taiwan

Design Draft (feet)	Number of Vessels	Average dwt	Average Departure Draft (feet)
34	7	31,355	35
35	5	30,814	35
36	13	37,589	36
37	3	39,567	37
41	1	45,332	39
44	1	70,415	40

Table 50. 1993 Wheat Vessel Movements to South Korea

Design Draft (feet)	Number of Vessels	Average dwt	Average Departure Draft (feet)
31	3	20,079	31
32	4	25,709	32
33	16	25,847	34
34	22	28,690	35
35	12	27,999	35
36	2	36,948	36
37	1	45,092	36
43	1	66,228	40

[9] Corn exports to Taiwan generally depart the Columbia River at the current channel constraint (39 or 40 feet).

Table 51. 1993 Columbia River Wheat Exports – Rapidly Developing Asia

Rounded Design Draft	Hong Kong	Indonesia	Malaysia	Republic of Korea	Taiwan	Thailand	Total Tons	Percent of Total
29	0	0	0	0	0	0	0	0
31	0	0	5,181	55,909	0	0	61,089	2
32	0	0	0	80,906	0	27,907	108,813	4
33	18,457	0	0	380,968	0	49,615	449,039	15
34	33,858	0	0	564,523	203,328	99,905	901,614	30
35	0	0	51,306	312,032	141,886	27,365	532,588	18
36	35,439	43,707	27,166	49,916	456,248	2,668	615,144	21
37	64,998	0	0	42,272	79,075	0	186,344	6
38	0	0	0	0	0	0	0	0
39	0	0	0	0	0	25,542	25,542	1
40	0	0	0	0	0	0	0	0
41	0	0	6,063	0	38,496	0	44,558	2
42	0	0	0	0	0	0	0	0
43	0	0	0	36,376	0	0	36,376	1
44	0	0	0	0	8,057	0	8,057	0
45	0	0	0	0	0	0	0	0
Totals	152,751	43,707	89,716	1,522,901	927,088	233,001	2,969,164	100

In general, it is expected that some of the countries in this region will expand capacity and channel depth to except Panamax size vessels. As the period of analysis begins in 2004, it is likely that many of these developing countries will improve their infrastructure and processing capabilities before the end of the period of analysis, but the immediate response to a Columbia River channel deepening is expected to be mixed. Relative to corn, wheat, being a food grain, is a higher-value commodity, and, thus, there is less pressure to decrease shipping and processing costs. Industry opinion gathered in interviews regarding developments was mixed. Some sources seemed to feel that there would be no developments in the foreseeable future. Other sources feel that changes were going to be happening over the next decade, and most of the wheat destination countries will have infrastructure in place to handle panamax size wheat vessels.

There are a number of reports of developments in these countries. Indonesia and Taiwan are constructing grain terminals to handle vessels as large as capesize[10]. Malaysia is planning improvements to handle grain panamax vessels[11]. Thailand's Southern Seaboard Development Program has accelerated their construction of a deep-sea port[12]. If these developments occur, it is likely that much of the wheat movements will be similar to much of the Columbia River corn movements, moving in large panamax vessels, drafting from 40 to 43 feet (depending on the depth of the Columbia River). Tables 52 and 53 display the wheat fleet projections for Rapidly Developing Asia. It is expected that, over time, most countries will develop infrastructure to take advantage of the channel deepening, but it is not expected that all tonnage will move on panamax vessels.

[10] Fairplay, 11th April, 1996.
[11] US Wheat Associates.
[12] The Journal of Commerce, July 28, 1995.

Table 52. Columbia River Base Condition Wheat Fleet - Rapidly Developing Asia

Design Draft (feet)	Average Departure Draft	1993 Wheat Tonnage	2004	2014	2024	2034	2044
31	31	2%	3%	2%	0%	0%	0%
32	32	4%	5%	4%	4%	4%	4%
33	33	15%	10%	9%	9%	9%	9%
34	34	30%	20%	15%	10%	10%	10%
35	35	18%	10%	7%	5%	5%	5%
36	36	21%	25%	8%	3%	3%	3%
37	37	6%	7%	5%	3%	3%	3%
38	38	0%					
39	39	1%					
40	40	0%					
41	40	2%	5%	12%	14%	14%	14%
42	40	0%	6%	13%	16%	16%	16%
43	40	1%	5%	15%	25%	25%	25%
44	40	0%	4%	10%	11%	11%	11%
Totals	---	100%	100%	100%	100%	100%	100%

Table 53. With-Project (43-foot Channel) Condition Wheat Fleet - Rapidly Developing Asia

Design Draft (feet)	Average Departure Draft	1993 Wheat Tonnage	2004	2014	2024	2034	2044
31	31	2%	3%	2%	0%	0%	0%
32	32	4%	5%	4%	4%	4%	4%
33	33	15%	10%	9%	9%	9%	9%
34	34	30%	20%	15%	10%	10%	10%
35	35	18%	10%	7%	5%	5%	5%
36	36	21%	25%	8%	3%	3%	3%
37	37	6%	7%	5%	3%	3%	3%
38	38	0%					
39	39	1%					
40	40	0%					
41	41	2%	5%	12%	14%	14%	14%
42	42	0%	6%	13%	16%	16%	16%
43	43	1%	5%	15%	25%	25%	25%
44	43	0%	4%	10%	11%	11%	11%
Totals	---	100%	100%	100%	100%	100%	100%

Tables 54 and 55 display the projected number of vessel trips for wheat vessels in the Rapidly Developing Asia trade route.

Table 54. Projected Number of Wheat Vessels, Rapidly Developing Asia, 40-foot Channel

Design Draft	2004	2014	2024	2034	2044	2054
31	6.3	5.1				
32	9.6	9.3	10.7	12.2	12.3	12.3
33	17.7	19.3	22.2	25.2	25.5	25.5
34	31.6	28.7	21.9	24.9	25.2	25.2
35	14.3	12.1	9.9	11.2	11.4	11.4
36	32.5	12.6	5.4	6.1	6.2	6.2
37	8.3	7.2	5.0	5.6	5.7	5.7
38						
39						
40						
41	4.0	11.6	15.6	17.7	17.9	17.9
42	4.8	12.5	17.6	20.0	20.3	20.3
43	3.9	14.0	26.8	30.5	30.9	30.9
44	3.1	9.2	11.7	13.3	13.4	13.4
45						
Total	136.1	141.5	146.8	166.8	168.8	168.8

Table 55. Projected Number of Wheat Vessels, Rapidly Developing Asia, 43-foot Channel

Design Draft	2004	2014	2024	2034	2044	2054
31	6.3	5.1				
32	9.6	9.3	10.7	12.2	12.3	12.3
33	17.7	19.3	22.2	25.2	25.5	25.5
34	31.6	28.7	21.9	24.9	25.2	25.2
35	14.3	12.1	9.9	11.2	11.4	11.4
36	32.5	12.6	5.4	6.1	6.2	6.2
37	8.3	7.2	5.0	5.6	5.7	5.7
38						
39						
40						
41	3.9	11.2	15.0	17.1	17.3	17.3
42	4.4	11.6	17.0	18.7	18.9	18.9
43	3.5	12.6	24.2	27.5	27.8	27.8
44	2.8	8.3	10.5	11.9	12.1	12.1
45						
Total	135.0	138.0	141.9	160.5	162.5	162.5

6.2.1.3. Other Asia

This region includes the Philippines, Pakistan, and Sri Lanka[13]. These countries currently receive more than 30 percent of Columbia River wheat exports. The Philippines is opening a new deep draft grain facility in Marivale, Bataan. This facility will be used for wheat and soybean meal. The facility will have the capacity to handle Panamax-size vessels. In 1993, the Philippines received over 1.5 million short tons of wheat, primarily in 35,000 to 45,000 ton lot sizes, departing Portland at drafts of 37 and 38 feet. As the Philippines continues to develop deep draft facilities, that lot sizes and vessel departure drafts are expected to generally increase to the channel constraint (in the with- and without-project conditions).

Shipments of wheat to Pakistan and Sri Lanka have generally moved in 58,000 short ton lot sizes, departing between 38 and 40 feet in draft. Without a channel deepening, it is expected that there will be little change in these vessels. In 1993, the design drafts of vessels carrying wheat to Pakistan and Sri Lanka varied from 41.78 to 43.8 feet, and it is unlikely that this would change in a without-project condition. With a channel deepening, it is expected that both lot sizes and vessel sizes will generally increase in size to match the average maximum load possible out of the Columbia River.

Tables 56, 57, and 58 display descriptive data for wheat destined for the Philippines, Pakistan, and Sri Lanka.

Table 56. 1993 Columbia River Wheat Tonnage to Other Asia

Rounded Design Draft (feet)	Bangladesh	Ceylon (Sri Lanka)	Pakistan	Philippines	Total Tons	Percent of Total
29	0	0	0	0	0	0%
31	0	0	0	0	0	0%
32	0	0	0	0	0	0%
33	0	20,715	0	0	20,715	1%
34	23,306	0	0	28,935	52,241	2%
35	0	0	0	37,478	37,478	1%
36	27,578	0	0	462,253	489,831	18%
37	61,234	0	0	395,067	456,301	17%
38	0	0	48,060	616,057	664,117	24%
39	0	0	0	0	0	0%
40	70,824	0	0	0	70,824	3%
41	28,937	55,795	0	0	84,732	3%
42	0	57,408	222,201	0	279,609	10%
43	0	57,408	176,368	0	233,776	9%
44	0	230,274	46,297	0	276,571	10%
45	0	56,962	0	0	56,962	2%
Grand Total	211,879	478,562	492,926	1,539,791	2,723,159	100%

[13] Actually, this group contains more than thirty countries in Asia, but the Philippines, Pakistan, and Sri Lanka are the three major destination countries.

In general, given that much of the traffic to countries in this region already move on panamax vessels, and, given that the Philippines is expected to improve its infrastructure, it is expected that most of the wheat moving to these countries will benefit from a channel deepening.

Table 57. Columbia River Base Condition Wheat Fleet - Other Asia

Design Draft (feet)	Average Departure	1993 Wheat Tonnage	2004	2014	2024	2034	2044
33	33	0.8%	1%	1%	1%	1%	1%
34	34	1.9%	2%	2%	2%	2%	2%
35	35	1.4%	1%	1%	1%	1%	1%
36	36	18.0%	15%	4%	3%	3%	3%
37	37	16.8%	15%	10%	7%	7%	7%
38	38	24.4%	20%	8%	5%	5%	5%
39	39	0.0%	1%	0%	0%	0%	0%
40	40	2.6%	1%	1%	1%	1%	1%
41	40	3.1%	4%	9%	10%	10%	10%
42	40	10.3%	14%	18%	20%	20%	20%
43	40	8.6%	10%	23%	25%	25%	25%
44	40	10.2%	12%	14%	15%	15%	15%
45	40	2.1%	4%	9%	10%	10%	10%
Totals	---	100%	100%	100%	100%	100%	100%

Table 58. With-Project (43-foot Channel) Condition Wheat Fleet - Other Asia

Design Draft (feet)	Average Departure	1993 Wheat Tonnage	2004	2014	2024	2034	2044
33	33	0.8%	1%	1%	1%	1%	1%
34	34	1.9%	2%	2%	2%	2%	2%
35	35	1.4%	1%	1%	1%	1%	1%
36	36	18.0%	15%	4%	3%	3%	3%
37	37	16.8%	15%	10%	7%	7%	7%
38	38	24.4%	20%	8%	5%	5%	5%
39	39	0.0%	1%	0%	0%	0%	0%
40	40	2.6%	1%	1%	1%	1%	1%
41	40	3.1%	4%	9%	10%	10%	10%
42	40	10.3%	14%	18%	20%	20%	20%
43	40	8.6%	10%	23%	25%	25%	25%
44	40	10.2%	12%	14%	15%	15%	15%
45	40	2.1%	4%	9%	10%	10%	10%
Totals	---	100%	100%	100%	100%	100%	100%

Tables 59 and 60 display the projected number of vessel trips for wheat vessels in the Other Asia trade route. The number of vessel trips grows slowly over time. The channel deepening typically provides a six percent decrease in vessel trips.

Table 59. Projected Number of Wheat Vessels, Other Asia, 40-foot Channel

Design Draft	2004	2014	2024	2034	2044	2054
31						
32						
33	2.4	2.1	2.3	3.2	3.3	3.3
34	4.3	3.8	4.2	5.7	5.9	5.9
35	1.9	1.7	1.9	2.6	2.7	2.7
36	26.5	6.3	5.1	7.0	7.2	7.2
37	24.3	14.3	11.0	15.0	15.5	15.5
38	30.6	10.8	7.4	10.1	10.5	10.5
39	1.4					
40	1.4	1.2	1.3	1.8	1.9	1.9
41	4.4	8.7	10.5	14.4	14.9	14.9
42	15.1	17.2	20.9	28.6	29.5	29.5
43	10.5	21.4	25.4	34.8	35.9	35.9
44	12.5	12.9	15.1	20.6	21.3	21.3
45	4.2	8.4	10.2	13.9	14.4	14.4
Total	139.5	108.9	115.3	157.8	163.0	163.0

Table 60. Projected Number of Wheat Vessels, Other Asia, 43-foot Channel

Design Draft	2004	2014	2024	2034	2044	2054
31						
32						
33	2.4	2.1	2.3	3.2	3.3	3.3
34	4.3	3.8	4.2	5.7	5.9	5.9
35	1.9	1.7	1.9	2.6	2.7	2.7
36	26.5	6.3	5.1	7.0	7.2	7.2
37	24.3	14.3	11.0	15.0	15.5	15.5
38	30.6	10.8	7.4	10.1	10.5	10.5
39	1.4					
40	1.4	1.2	1.3	1.8	1.9	1.9
41	4.2	8.4	10.2	13.9	14.4	14.4
42	14.1	16.6	19.5	26.6	27.5	27.5
43	9.5	19.3	22.9	31.4	32.4	32.4
44	11.2	11.6	13.6	18.6	19.2	19.2
45	3.8	7.5	9.1	12.5	12.9	12.9
Total	135.7	103.7	108.5	148.5	153.3	153.3

6.2.1.4. Other Region (Africa, Latin America, and the Middle East)

There are a number of other countries that also import wheat from the Columbia River in small amounts. Approximately 10 to 15 percent of wheat tonnage will go to countries in Africa and the Middle East, including Egypt, South Africa, Sudan, Ethiopia, Jordan, Kuwait, Saudi Arabia, and Yemen. In 1993, approximately half of this tonnage moved at a departure draft of 39 or 40 feet. Egypt and Saudi Arabia accounted for approximately two-thirds of this tonnage. Exports to Egypt and Saudi Arabia move on Panamax size vessels with design drafts of 41 to 45 feet and dead weight tonnage of 65,000 to 73,000, in approximately 58,000 ton lot sizes, which is considered the average maximum load for the Columbia River. In the without-project condition, it is expected that there will be little change in these movements. The vessels are already of greater capacity than the current channel can fully utilize.

With a channel deepening, two changes would occur with the movements to Egypt and Saudi Arabia. First, the average lot size would shift to fully utilize the channel depth. Second, over time, it is likely that the majority of vessels will shift slightly to sizes that could fully load in the with-project channel depth.

For vessels carrying wheat to other destinations in Africa and the Middle East (approximately four percent of total Columbia River wheat exports), lot sizes and operating drafts vary. Currently, more than two-thirds of this tonnage could benefit from a channel deepening. In the future, as some of these countries improve their infrastructure, it is expected that an increasing amount of this tonnage will depart the Columbia on panamax size vessels, making full use of the channel depth.

Table 61 displays 1993 Columbia River wheat exports to all other countries not included in the previously mentioned regions. As can be seen, much of this tonnage could currently benefit from a channel deepening. It is expected that, regardless of the Columbia River channel depth, there will always be some portion of the tonnage which, for various reasons, will not benefit from the channel deepening.

Tables 62 and 63 display the fleet projections for wheat going to the Other region. It is expected, in both the with-project condition and the base condition that much of the existing fleet would continue to call the Columbia River. It is also expected that, over time, as some of the countries in this region continue to improve their infrastructure, some of the tonnage currently moving in handy size and handy-max size vessels will gradually shift to panamax vessels.

Table 61. Columbia River Wheat Exports – Other Region, 1993

Rounded Design Draft	Egypt	Ethiopia	Jordan	Kenya	Kuwait	Rep. of South Africa	Saudi Arabia	Sudan	Uar Egypt	Yemen Arab Republic	Brazil	Chile	Colombia	El Salvador	Total Tons	Percent of Tons
32				28,015									25,463	44,451	97,929	4
33											18,519				18,519	1
34					26,109										26,109	1
35					25,832			27,212							53,044	2
36		10,683							34,724	120,766					166,174	6
37					34,396	71,676			34,722	134,044		89,533			364,372	14
38						69,356	42,549			143,805					255,710	10
39										31,526					31,526	1
40										37,392					37,392	1
41						39,134			57,732	73,082					169,948	6
42	115,742						138,890		231,490						486,121	18
43	115,745						115,742		57,871						289,357	11
44			57,871				115,742		231,483						405,095	15
45							172,080		57,871						229,951	9
Totals	231,486	10,683	57,871	28,015	86,338	180,166	585,002	27,212	705,893	540,616	18,519	89,533	25,463	44,451	2,631,246	100

Table 62. Columbia River Base Condition Wheat Fleet – Other Region

Design Draft (feet)	Average Departure Draft	1993 Percent of Tons	2004	2014	2024	2034	2044
32	32	4%	1%	1%	1%	1%	1%
33	33	1%	1%	2%	1%	1%	1%
34	34	1%	1%	1%	1%	1%	1%
35	35	2%	5%	4%	2%	2%	2%
36	36	6%	5%	5%	5%	5%	5%
37	37	14%	10%	8%	6%	6%	6%
38	38	10%	8%	5%	5%	5%	5%
39	39	1%	1%	1%	1%	1%	1%
40	40	1%	1%	1%	1%	1%	1%
41	40	6%	10%	10%	10%	10%	10%
42	40	18%	20%	20%	20%	20%	20%
43	40	11%	12%	14%	15%	15%	15%
44	40	15%	15%	16%	17%	17%	17%
45	40	9%	10%	12%	15%	15%	15%
Totals	---	100%	100%	100%	100%	100%	100%

Table 63. With-Project (43-foot Channel) Condition Wheat Fleet – Other Region

Design Draft (feet)	Average Departure Draft	1993 Percent of Tons	2004	2014	2024	2034	2044
32	32	4%	1%	1%	1%	1%	1%
33	33	1%	1%	2%	1%	1%	1%
34	34	1%	1%	1%	1%	1%	1%
35	35	2%	5%	4%	2%	2%	2%
36	36	6%	5%	5%	5%	5%	5%
37	37	14%	10%	8%	6%	6%	6%
38	38	10%	8%	5%	5%	5%	5%
39	39	1%	1%	1%	1%	1%	1%
40	40	1%	1%	1%	1%	1%	1%
41	40	6%	10%	10%	10%	10%	10%
42	40	18%	20%	20%	20%	20%	20%
43	40	11%	12%	14%	15%	15%	15%
44	40	15%	15%	16%	17%	17%	17%
45	40	9%	10%	12%	15%	15%	15%
Totals	---	100%	100%	100%	100%	100%	100%

Tables 64 and 65 display the projected number of vessel trips for wheat vessels in the Other trade route. The number of vessel trips grows slowly over time. The channel deepening typically provides a 5.5 percent decrease in vessel trips.

Table 64. Projected Number of Wheat Vessels, Other Region, 40-foot Channel

Design Draft	2004	2014	2024	2034	2044	2054
31						
32	0.9	0.9	0.9	1.1	1.1	1.1
33	0.8	1.6	0.9	1.0	1.0	1.0
34	0.7	0.7	0.8	0.9	0.9	0.9
35	3.2	2.5	1.4	1.6	1.7	1.7
36	2.9	2.9	3.1	3.7	3.8	3.8
37	5.3	4.2	3.4	4.1	4.2	4.2
38	4.0	2.5	2.7	3.2	3.3	3.3
39	0.5	0.5	0.5	0.6	0.6	0.6
40	0.5	0.5	0.5	0.6	0.6	0.6
41	3.6	3.6	3.9	4.6	4.7	4.7
42	7.1	7.1	7.6	9.1	9.3	9.3
43	4.2	4.8	5.6	6.7	6.8	6.8
44	5.1	5.4	6.2	7.5	7.6	7.6
45	3.5	4.1	5.6	6.7	6.8	6.8
	42.2	41.3	43.0	51.4	52.4	52.4

Table 65. Projected Number of Wheat Vessels, Other Region, 43-foot Channel

Design Draft	2004	2014	2024	2034	2044	2054
31						
32	0.9	0.9	0.9	1.1	1.1	1.1
33	0.8	1.6	0.9	1.0	1.0	1.0
34	0.7	0.7	0.8	0.9	0.9	0.9
35	3.2	2.5	1.4	1.6	1.7	1.7
36	2.9	2.9	3.1	3.7	3.8	3.8
37	5.3	4.2	3.4	4.1	4.2	4.2
38	4.0	2.5	2.7	3.2	3.3	3.3
39	0.5	0.5	0.5	0.6	0.6	0.6
40	0.5	0.5	0.5	0.6	0.6	0.6
41	3.5	3.4	3.7	4.4	4.5	4.5
42	6.6	6.6	7.1	8.5	8.7	8.7
43	3.7	4.3	5.0	6.0	6.1	6.1
44	4.6	4.9	5.6	6.7	6.8	6.8
45	3.1	3.7	5.0	6.0	6.1	6.1
	40.3	39.2	40.7	48.6	49.5	49.5

6.2.2. Corn

Columbia River corn exports are expected to grow from 4.7 million tons in 2004 to 8.8 million tons in 2054. Much of this growth will be a result of increased exports to rapidly developing Asian countries (Malaysia, Indonesia, and South Korea) and China. In general, lot sizes for corn out of the Pacific Northwest are driven by what can typically be carried out of the Columbia. This means that the companies put out a tender for an amount of grain that can be typically carried out of the Columbia River, within a five to ten percent range. Corn sellers then bid on the tender, and the sale goes to the lowest bidder. The tender includes details regarding the quantity and quality of the corn, and it will also specify a time range during which the buyer will make a vessel available to receive the corn, and from which region of the United States the buyer would like to pick up the grain. Typically the load size is determined by the average amount of grain which can be loaded in the Columbia River, even though the buyer will specify the Pacific Northwest Region, which includes the (relatively unconstrained) Puget Sound. After bidding occurs, and a seller is selected, the buyer sends a vessel to pick up the grain. When the vessel is approximately ten days away from the West Coast, the vessel operator will contact the seller to determine the load port nominated[14].

Typical maximum lot sizes range from 50,000 to 54,000 tons, with a range of plus or minus five percent allowed. It is within the Captain's area of responsibility to decide how deep to load a vessel. The Captain will declare the amount he expects to load based on restrictions of the vessel, load port, discharge port, and contract. Any of these constraints might be the limiting factor.

There are a number of reasons why a load might vary from the maximum possible draft:

- The vessel characteristics are such that the vessel is full by volume before reaching the channel constraint or design draft.
- The vessel is large enough to reach the maximum amount allowed under the contract before reaching the channel constraint or design draft.
- The destination port (or buyer's facilities) has a constraint which is less than the Columbia River channel constraint. These transactions will often be contracted to vessels that are handy-sized. According to industry experts, it is expected that in the long-term, there will always be some small portion of the corn fleet that will operate within these constraints.

Tables 66 and 67 displays the 1993 vessel movements for corn out of the Columbia River. The majority of the corn left at the channel constraint depth.

[14] A seller might have facilities at multiple locations in the Pacific Northwest Region.

Table 66. 1993 Columbia River Corn Vessel Movements

Design Draft (feet)	Typical Maximum Draft	Typical Average Draft	Percent of Vessels	Percent of Tons	Total Tons Carried	Number of Vessels	Average dwt	Average Load
36	36	35	12.90	7.93	244,507	8	41,780	30,563
37	37	36	16.13	13.25	408,690	10	45,833	40,869
38	38	37	6.45	4.98	153,626	4	44,744	38,406
39	39	38	0	0	0	0		
40	40	39	0	0	0	0		
41	40	40	3.23	3.74	115,295	2	72,413	57,648
42	40	40	19.35	21.91	675,616	12	67,445	56,301
43	40	40	16.13	18.97	585,021	10	71,605	58,502
44	40	40	19.35	22.02	679,142	12	73,750	56,595
45	40	40	4.84	5.39	166,323	3	75,651	55,441
46	40	40	1.61	1.80	55,351	1	84,198	55,351
Totals	---	---	100.00	100.00	3,083,571	62	---	---

Table 67. 1993 Columbia River Corn Export Tonnage by Destination

(short tons)

	Outbound Draft (feet)						
Foreign Port Destination	33	35	36	37	38	39	40
Japan		41,054	122,666	396,262	164,996	106,235	374,092
New Zealand		6,614					
Republic Of Korea						119,864	
Taiwan	34,722	40,510				842,509	834,048
Grand Total	34,722	88,177	122,666	396,262	164,996	1,068,608	1,208,140

The Japanese and Taiwanese markets have historically been one of the dominant destinations for Columbia River corn exports. Unlike wheat shipments to Japan, corn vessels generally depart the Columbia River at drafts that approach the channel constraint. It is expected that much of the corn that currently moves at the channel constraint will shift (in a with-project condition) to the deepest possible draft.

Tables 68 and 69 display 1993 information concerning corn vessel movements to Japan and Taiwan. Note that the current fleet already has a considerable number of large Panamax-size vessels that are lightloading.

Table 68. 1993 Corn Vessel Movements to Japan

	Rounded Design Draft (feet)						
	36	37	38	42	43	44	45
Number of Vessels	5	9	4	2	4	3	1
Average of Dwt	42,732	46,163	44,744	67,810	71,816	74,960	71,069
Average of Rounded Departure Draft	36	36	38	40	40	40	40

Table 69. 1993 Corn Vessel Movements to Taiwan

	Rounded Design Draft (feet)							
	36	**37**	**41**	**42**	**43**	**44**	**45**	**46**
Number of Vessels	2	1	2	8	6	9	2	1
Average of Dwt	41,472	42,866	72,413	67,415	71,464	73,346	77,942	84,198
Average of Rounded Departure Draft	35	33	40	40	40	40	40	39

It is clear that much of the existing traffic would benefit from a channel deepening, but future corn destinations are expected to include a greater variety of countries. Tables 70 and 71 display projected Columbia River corn movements over the period of analysis.

Table 70. Columbia River Corn Forecasts

(millions of short tons)

Year	Japan	China	Rapidly Developing Asia
2004	1,086,000	724,000	3,276,000
2014	982,000	1,081,000	3,895,000
2024	936,000	1,251,000	4,796,000
2034	1,151,000	1,774,000	6,266,000
2044	1,155,000	1,984,000	6,326,000
2054	1,168,000	2,008,000	6,402,000

Table 71. Columbia River Corn Forecasts

(percent of total by destination)

Destination	2004	2014	2024	2034	2044
China	14%	18%	18%	19%	21%
Japan	21%	16%	13%	12%	12%
Other Asia	1%	1%	1%	1%	1%
Rapidly Developing Asia	64%	65%	68%	67%	66%
Total	100%	100%	100%	100%	100%

6.2.2.1. Japan

Japan has historically utilized the existing channel depth with a fair degree of efficiency. While much of the existing traffic has moved in design drafts greater than the channel constraint, there has still been a portion of the corn tonnage that has moved at drafts from 36 to 37 feet. It is possible that these movements are constrained either by destination draft or destination storage or processing capacity. Corn is a low-value feed grain, and economic forces will always be strong to transport and process corn in the cheapest manner possible, meaning that there is strong pressure to move corn in the largest possible quantities. However, it is also acknowledged that there are factors like existing facilities and infrastructure that can limit the size of shipment. Based on historical trends, and the general trend for Panamax vessels to continue to grow in average size, Tables 72 and 73 present the base condition and with-project (43-foot) condition fleets.

Table 72. Columbia River Base Condition Corn Fleet - Japan

Design Draft (feet)	1993 Distribution of Corn Exports	Typical Average Operating Draft	Projected Distribution of Corn Exports				
			2004	2014	2024	2034	2044
36	16%	36	15%	10%	10%	10%	10%
37	31%	37	30%	27%	25%	25%	25%
38	13%	38	10%	7%	5%	5%	5%
39	0%	39					
40	0%	40					
41	0%	40					
42	6%	40	5%	9%	10%	10%	10%
43	18%	40	20%	23%	22%	22%	22%
44	12%	40	15%	18%	21%	21%	21%
45	3%	40	5%	6%	7%	7%	7%
Totals	100%		100%	100%	100%	100%	100%

Table 73. With-Project (43-foot Channel) Corn Fleet - Japan

Design Draft (feet)	1993 Distribution of Corn Exports	Typical Average Operating Draft	Projected Distribution of Corn Exports				
			2004	2014	2024	2034	2044
36	16%	36	15%	10%	10%	10%	10%
37	31%	37	30%	27%	25%	25%	25%
38	13%	38	10%	7%	5%	5%	5%
39	0%	39					
40	0%	40					
41	0%	41					
42	6%	42	5%	9%	10%	10%	10%
43	18%	43	20%	23%	22%	22%	22%
44	12%	43	15%	18%	21%	21%	21%
45	3%	43	5%	6%	7%	7%	7%
Total	100%		100%	100%	100%	100%	100%

Tables 74 and 75 display the projected number of vessel trips for those vessels carrying corn to Japan.

Table 74. Projected Number of Corn Vessels, Japan, 40-foot Channel

Design Draft	2004	2014	2024	2034	2044	2054
36	4.7	2.8	2.7	3.3	3.3	3.4
37	8.6	7.0	6.2	7.6	7.7	7.7
38	2.7	1.7	1.2	1.4	1.4	1.5
39						
40						
41						
42	1.0	1.6	1.7	2.0	2.0	2.1
43	3.7	3.9	3.5	4.4	4.4	4.4
44	2.8	3.0	3.3	4.1	4.1	4.2
45	0.9	1.0	1.1	1.4	1.4	1.4
46						
Totals	24.5	21.0	19.7	24.3	24.3	24.6

Table 75. Projected Number of Corn Vessels, Japan, 43-foot Channel

Design Draft	2004	2014	2024	2034	2044	2054
36	4.7	2.8	2.7	3.3	3.3	3.4
37	8.6	7.0	6.2	7.6	7.7	7.7
38	2.7	1.7	1.2	1.4	1.4	1.5
39						
40						
41						
42	0.9	1.5	1.5	1.9	1.9	1.9
43	3.4	3.5	3.2	3.9	3.9	4.0
44	2.5	2.7	3.0	3.7	3.7	3.8
45	0.8	0.9	1.0	1.2	1.2	1.3
46						
Totals	23.7	20.1	18.8	23.1	23.2	23.5

6.2.2.2. China

Historically, China has not been a major importer of corn from the Pacific Northwest. In fact, China produces a large amount of grain domestically. Nonetheless, domestic prices are very high, roughly $40 to $50 per ton higher that U.S. prices. Consumption continues to grow in line with China's rapid economic expansion and its emerging middle class. China's feed sector is expanding rapidly, but the underlying factors that drive demand are forecast to continue to grow. Rising consumer incomes, working spouses, and a more open environment are raising expectations and generating more demand for meat and eggs, snack and convenience foods.

Shipping sources are now reporting that "growth in demand from south-east Asian markets is forcing countries like China to build new grain terminals to handle the modern fleet of capesize vessels with deeper draught.[15]" While it is unlikely that grain from the Columbia River will move in capesize vessels, it is likely that Columbia River corn exports will move in large Panamax size vessels.

Given the industry expectations for development of facilities to handle even larger capesize vessels, it is expected that corn shipments to China will generally move in Panamax vessels of 42 to 45 feet in design draft, much as the current Japanese fleet operates, but with a much smaller portion of the corn moving at lesser drafts (Tables 76 and 77).

Table 76. Columbia River Base Condition Corn Fleet - China

Design Draft (feet)	**Typical Average Operating Draft**	**Projected Distribution of Corn Exports**				
		2004	**2014**	**2024**	**2034**	**2044**
36	36	15%	5%	4%	4%	4%
37	37	20%	7%	5%	5%	5%
38	38	20%	7%	5%	5%	5%
39	39	13%	5%	4%	4%	4%
40	40					
41	40					
42	40	10%	10%	10%	10%	10%
43	40	10%	25%	27%	27%	27%
44	40	7%	25%	25%	25%	25%
45	40	5%	16%	20%	20%	20%
Totals		100%	100%	100%	100%	100%

Table 77. With-Project (43-foot Channel) Corn Fleet - China

Design Draft (feet)	**Typical Average Operating Draft**	**Projected Distribution of Corn Exports**				
		2004	**2014**	**2024**	**2034**	**2044**
36	36	15%	5%	4%	4%	4%
37	37	20%	7%	5%	5%	5%
38	38	20%	7%	5%	5%	5%
39	39	13%	5%	4%	4%	4%
40	40					
41	41					
42	42	10%	10%	10%	10%	10%
43	43	10%	25%	27%	27%	27%
44	43	7%	25%	25%	25%	25%
45	43	5%	16%	20%	20%	20%
Totals		100%	100%	100%	100%	100%

[15] Fairplay, 11th April, 1996.

Tables 78 and 79 display the projected number of vessel trips for those vessels carrying corn to China.

Table 78. Projected Number of Corn Vessels, China, 40-foot Channel

Design Draft	2004	2014	2024	2034	2044	2054
36	3.1	1.6	1.4	2.0	2.3	2.3
37	3.8	2.0	1.7	2.4	2.6	2.7
38	3.6	1.9	1.6	2.2	2.5	2.5
39	2.2	1.3	1.2	1.7	1.9	1.9
40						
41						
42	1.3	1.9	2.2	3.1	3.5	3.5
43	1.2	4.6	5.8	8.2	9.2	9.3
44	0.9	4.6	5.3	7.5	8.4	8.5
45	0.6	3.0	4.3	6.1	6.8	6.9
46						
Totals	16.8	20.9	23.5	33.3	37.2	37.7

Table 79. Projected Number of Corn Vessels, China, 43-foot Channel

Design Draft	2004	2014	2024	2034	2044	2054
36	3.1	1.6	1.4	2.0	2.3	2.3
37	3.8	2.0	1.7	2.4	2.6	2.7
38	3.6	1.9	1.6	2.2	2.5	2.5
39	2.2	1.3	1.2	1.7	1.9	1.9
40						
41						
42	1.2	1.8	2.1	2.9	3.3	3.3
43	1.1	4.2	5.2	7.4	8.3	8.4
44	0.8	4.1	4.8	6.8	7.6	7.7
45	0.6	2.7	3.9	5.5	6.1	6.2
46						
Totals	16.5	19.5	21.8	30.9	34.6	35.0

6.2.2.3. Rapidly Developing Asia

The majority of increases in corn exports over the period of analysis are expected be a result of increases in demand from countries like Taiwan, Korea, Malaysia, Indonesia, and Thailand. As these economies grow, so will their demand for feed grains. Many of these countries have the advantage of being unhampered by old and undersized facilities, and as the economies have grown, so has interest in producing infrastructure that allows for efficiently importing feed grains. Almost all of these countries have either recently completed improvements in their grain handling facilities or are in the process of improving them.

Exports to Taiwan have been strong throughout the 1990s, with lot sizes generally ranging from 55,000 to 62,000 short tons, moving on 67,000 to 72,000 dwt vessels. Table 80 displays 1993 Columbia River corn exports to Taiwan.

Table 80. 1993 Columbia River Corn Vessel Movements

Design Draft (feet)	Number of Vessels	Average Departure Draft	Tons Carried	Percent of Tons Carried
36	2	35	40,510	2
37	1	33	34,722	2
38				
39				
40				
41	2	40	115,295	7
42	8	40	477,520	27
43	6	40	367,475	21
44	9	40	535,915	31
45	2	40	125,001	7
46	1	39	55,351	3
Totals	31		1,751,788	100

There is very little history of commodity movements from the Columbia River to many of the other countries in this region, but there are a number of reports of developments in these countries. Indonesia and Taiwan are constructing grain terminals to handle vessels as large as capesize[16]. Malaysia is planning improvements to handle grain panamax vessels[17]. Thailand's Southern Seaboard Development Program has accelerated their construction of a deep-sea port[18]. If these developments occur, much of the corn moving to this region are projected to be quite similar to current movements to Taiwan.

It is likely that much of the corn moving to this region will move in large Panamax class vessels, but, as is reflected in Tables 81 and 82, there is uncertainty in these movements, given that (other than Taiwan) there is relatively little history of corn movements[19].

[16] Fairplay, 11th April, 1996.
[17] US Wheat Associates.
[18] The Journal of Commerce, July 28, 1995.
[19] Uncertainty in the fleet projections will be addressed in the Risk and Uncertainty Section.

Table 81. Columbia River Base Condition Corn Fleet - Rapidly Developing Asia

Design Draft (feet)	1993 Distribution of Corn Exports to Taiwan	Typical Average Operating Draft	Projected Distribution of Corn Exports				
			2004	**2014**	**2024**	**2034**	**2044**
36	2%	36	8%	7%	5%	5%	5%
37	2%	37	10%	8%	6%	5%	4%
38		38	8%	7%	6%	5%	4%
39		39					
40		40					
41	7%	40	5%	4%	1%	1%	1%
42	27%	40	15%	14%	14%	14%	14%
43	21%	40	24%	25%	25%	25%	25%
44	31%	40	21%	21%	23%	24%	25%
45	7%	40	5%	10%	15%	15%	15%
46	3%	40	4%	4%	5%	6%	7%
Totals	100%		100%	100%	100%	100%	100%

Table 82. With-Project (43-foot Channel) Corn Fleet - Rapidly Developing Asia

Design Draft (feet)	1993 Distribution of Corn Exports to Taiwan	Typical Average Operating Draft	Projected Distribution of Corn Exports				
			2004	**2014**	**2024**	**2034**	**2044**
36	2%	36	8%	7%	5%	5%	5%
37	2%	37	10%	8%	6%	5%	4%
38		38	8%	7%	6%	5%	4%
39		39					
40		40					
41	7%	41	5%	4%	1%	1%	1%
42	27%	42	15%	14%	14%	14%	14%
43	21%	43	24%	25%	25%	25%	25%
44	31%	43	21%	21%	23%	24%	25%
45	7%	43	5%	10%	15%	15%	15%
46	3%	43	4%	4%	5%	6%	7%
	100%		100%	100%	100%	100%	100%

Tables 83 and 84 display the projected number of vessel trips for those vessels carrying corn to the Rapidly Developing Asia region.

Table 83. Projected Number of Corn Vessels, Rapidly Developing Asia, 40-foot Channel

Design Draft	2004	2014	2024	2034	2044	2054
36	7.6	7.9	6.9	9.0	9.1	9.2
37	8.7	8.3	7.6	8.3	8.4	8.5
38	6.6	6.8	7.2	7.8	7.9	8.0
39						
40						
41	2.9	2.8	0.9	1.1	1.1	1.1
42	8.7	9.6	11.9	15.5	15.6	15.8
43	13.5	16.7	20.6	26.9	27.2	27.5
44	11.7	13.9	18.7	25.5	25.8	26.1
45	2.8	6.7	12.4	16.2	16.3	16.5
46	2.2	2.6	4.0	6.3	6.4	6.5
Totals	64.6	75.3	90.2	116.8	117.9	119.3

Table 84. Projected Number of Corn Vessels, Rapidly Developing Asia, 43-foot Channel

Design Draft	2004	2014	2024	2034	2044	2054
36	7.6	7.9	6.9	9.0	9.1	9.2
37	8.7	8.3	7.6	8.3	8.4	8.5
38	6.6	6.8	7.2	7.8	7.9	8.0
39						
40						
41	2.8	2.7	0.8	1.1	1.1	1.1
42	8.1	9.0	11.1	14.4	14.6	14.8
43	12.2	15.1	18.6	24.3	24.5	24.8
44	10.5	12.5	16.9	23.0	23.2	23.5
45	2.5	6.0	11.1	14.5	14.7	14.8
46	2.0	2.4	3.6	5.7	5.7	5.8
Totals	60.9	70.6	83.8	108.2	109.2	110.6

6.2.3. Barley

Barley, in terms of volume, is a lesser export commodity for the Columbia River. In 1993, there were only approximately a dozen vessels moving barley out of the Columbia, carrying the cargo to Cyprus, Japan, Israel, Algeria, and Jordan. As seen inTable 85, more than half the barley-carrying vessels departed at drafts approaching the channel constraint. In general, it is expected that barley exports will remain relatively flat over the period of analysis, averaging approximately 750,000 short tons annually[20] (Table 85).

Barley, used as an alternate feed grain (as well as for malting), is likely to shift slightly, but not consistently, to larger vessels with a channel deepening. Industry experts have stated that Columbia River barley movements are difficult to predict, but that 1993 was a relatively normal year, and that future exports can reasonably be expected to follow a

[20] No country level forecasts are provided for barley.

similar pattern as was seen in 1993. Given the relatively small number of vessels carrying barley in 1993, the future fleets are expected to consist of a similar proportion of tonnage moving in vessels with design drafts greater than 40 feet, but the tonnage will be spread over appropriate ranges of design drafts.

Table 85. 1993 Columbia River Barley Exports

Design Draft (feet)	Typical Maximum Draft	Typical Average Draft	Percent of Vessels	Percent of Tons	Number of Vessels	Actual Tons	Average dwt	Average Tons Carried
33	33	32	18.18	12.58	2	50,550	29,215	25,275
34	34	33						
35	35	34						
36	36	35						
37	37	36	27.27	21.33	3	85,727	38,617	28,576
38	38	37						
39	39	38	9.09	6.73	1	27,046	33,670	27,046
40	40	39						
41	40	39	9.09	13.66	1	54,915	67,675	54,915
42	40	39	18.18	26.68	2	107,232	67,585	53,616
43	40	39						
44	40	39						
45	40	39	18.18	19.02	2	76,421	73,080	38,211
Totals	---	---	100.00	100.00	11	401,892	---	---

Table 86. Columbia River Base Condition Barley Fleet

Design Draft (feet)	Typical Average Draft	1993 Percent of Tons	2004	2014	2024	2034	2044	2054
33	33	12.58	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
34	34		5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
35	35		5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
36	36		5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
37	37	21.33	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
38	38		5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
39	39	6.73	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
40	40		6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
41	40	13.66	11.00%	11.00%	11.00%	11.00%	11.00%	11.00%
42	40	26.68	12.00%	12.00%	12.00%	12.00%	12.00%	12.00%
43	40		12.00%	12.00%	12.00%	12.00%	12.00%	12.00%
44	40		12.00%	12.00%	12.00%	12.00%	12.00%	12.00%
45	40	19.02	12.00%	12.00%	12.00%	12.00%	12.00%	12.00%
Totals		100.00	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table 87. Columbia River With-Project (43-foot Channel) Barley Fleet

Design Draft (feet)	Typical Average Draft	1993 Percent of Tons	2004	2014	2024	2034	2044	2054
33	33	12.58	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
34	34		5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
35	35		5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
36	36		5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
37	37	21.33	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
38	38		5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
39	39	6.73	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
40	40		6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
41	41	13.66	11.00%	11.00%	11.00%	11.00%	11.00%	11.00%
42	42	26.68	12.00%	12.00%	12.00%	12.00%	12.00%	12.00%
43	43		12.00%	12.00%	12.00%	12.00%	12.00%	12.00%
44	43		12.00%	12.00%	12.00%	12.00%	12.00%	12.00%
45	43	19.02	12.00%	12.00%	12.00%	12.00%	12.00%	12.00%
Totals		100.00	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Tables 88 and 89 display the projected number of vessel trips for those vessels carrying barley.

Table 88. Projected Number of Barley Vessels, 40-foot Channel

Design Draft	2004	2014	2024	2034	2044	2054
33	1.8	2.0	2.2	2.1	2.1	2.1
34	1.6	1.8	2.0	1.9	1.9	1.9
35	1.5	1.6	1.8	1.7	1.7	1.7
36	1.3	1.5	1.6	1.5	1.6	1.6
37	1.2	1.3	1.5	1.4	1.4	1.4
38	1.1	1.3	1.4	1.3	1.4	1.4
39	1.1	1.2	1.3	1.3	1.3	1.3
40	1.3	1.4	1.5	1.5	1.5	1.5
41	1.8	2.0	2.2	2.1	2.1	2.1
42	1.9	2.1	2.4	2.3	2.3	2.3
43	1.9	2.1	2.3	2.2	2.2	2.2
44	1.9	2.0	2.3	2.2	2.2	2.2
45	1.9	2.1	2.3	2.2	2.2	2.2
	20.3	22.2	24.5	23.6	24.1	24.1

Table 89. Projected Number of Barley Vessels, 43-foot Channel

Design Draft	2004	2014	2024	2034	2044	2054
33	1.8	2.0	2.2	2.1	2.1	2.1
34	1.6	1.8	2.0	1.9	1.9	1.9
35	1.5	1.6	1.8	1.7	1.7	1.7
36	1.3	1.5	1.6	1.5	1.6	1.6
37	1.2	1.3	1.5	1.4	1.4	1.4
38	1.1	1.3	1.4	1.3	1.4	1.4
39	1.1	1.2	1.3	1.3	1.3	1.3
40	1.3	1.4	1.5	1.5	1.5	1.5
41	1.7	1.9	2.1	2.0	2.1	2.1
42	1.8	2.0	2.2	2.1	2.1	2.1
43	1.7	1.9	2.1	2.0	2.0	2.0
44	1.7	1.8	2.0	2.0	2.0	2.0
45	1.7	1.9	2.1	2.0	2.0	2.0
	19.6	21.4	23.6	22.7	23.2	23.2

6.2.4. Alumina

Alumina is an import to the Columbia River, serving Pacific Northwest smelters. Alumina is generally imported from Australia in lot sizes from 30,000 to 40,000 short tons. Industry sources have stated that the Columbia River channel depth is not a constraint to their operations. Currently, off-loading and storage facilities limit useful vessel size. In this case, unlike the grain bulk commodities, it is local infrastructure that would have to change in order for alumina vessels to make use of a deeper channel.

Forecasts from the Bonneville Power Administration and the Northwest Power Planning Council are predicting that Pacific Northwest smelters will operate at approximately 85 to 90 percent of their current capacity throughout the next 30 years. While some plant modernization will occur to meet environmental regulations and to become more competitive internationally, this forecast assumes no expansion of local capacity. Alumina imports are expected to remain fluctuate around 1.3 million short tons a year, with the majority of the uncertainty in the forecast indicating that alumina imports are more likely to decrease than to increase. Given these factors, this analysis will forecast that a channel deepening will not impact alumina imports (Table 90).

Table 90. 1993 Columbia River Alumina Imports

Design Draft (feet)	Typical Maximum Draft	Typical Average Draft	Percent of Vessels	Percent of Tons	Number of Vessels	Actual Tons	Average Tons Carried	Average dwt
33	33	31	2.38	1.17	1	17,361	17,361	42,928
34	34	32	4.76	2.60	2	38,581	19,290	30,126
35	35	33	4.76	3.59	2	53,301	26,651	29,802
36	36	34	16.67	16.48	7	244,687	34,955	40,264
37	37	35	64.29	69.82	27	1,036,493	38,389	47,758
38	38	36	7.14	6.34	3	94,116	31,372	44,848
Totals	---	---	100.00	100.00	42	1,484,540	---	---

7. VESSEL OPERATING COSTS AND PRACTICES

This section describes the two primary inputs to the calculation of transportation costs. First, daily vessel operating costs show the efficiencies that can be achieved through fully loading vessels calling on the Columbia. Secondly, the number of days in-port and at-sea are critical elements in calculating the total transportation costs for each ton of commodity exported from the Columbia.

7.1. Vessel Operating Costs

Vessel operating costs are used to determine total transportation costs. As vessels get larger and deeper, they typically carry more tonnage. While the absolute cost of a larger vessel is greater than a smaller vessel, per-unit cost is typically smaller due to increased number of units carried.

Vessel operating cost data was obtained from Economic Guidance Memorandum 98-2, published by the Institute for Water Resources (IWR). IWR publishes estimates of annual operating costs for various sizes and types of vessels, both “at sea” and “in port” for use by Corps planners in determining comparative transportation costs and the potential benefits of harbor improvement projects.

Total fixed costs are the same for vessels “in port” and “at sea”. Total annual fixed costs consist of fixed annual operating costs and a replacement cost amortized using a capital recovery factor (CRF). Fuel costs are substantially different for vessels “in port” and “at sea”.

Fixed annual operating costs are comprised of: wages, benefits, and subsistence; stores and supplies; maintenance and repair; insurance; administration; and, other costs. Wages and benefits are payments to labor for vessel crewing. Subsistence includes food and uniform costs for crews. Stores and supply costs include material required for vessel operations other than fuel, such as galley operations, and laundry. Maintenance and repair expenditures are for average life-cycle operating maintenance and overhaul. Insurance costs consist of hull and machinery (H&M), and protection and indemnity

(P&I) insurance coverage. H&M insures against vessel loss at sea. P&I insures against claims arising from injury or death of crew members, passengers, third parties and pier and harbor works. Other costs include miscellaneous line haul expenses. They do not include port fees, tug assistance, or vessel loading or unloading.

In order to facilitate risk and uncertainty analysis, additional data was used to show the variable relationship between the design draft of a bulk vessel and its capacity[21]. This was done using the Clarkson World Fleet Characteristics Data. Using a program called *Best Fit*, distributions of of this relationship were constructed. The distributions were then used in *@Risk* to quantify the differences in benefits associated with the design draft-dwt relationship. In representing the dwt of each vessel as a distribution, rather than a point estimate, the variance of the world fleet can be represented in the calculation of the benefits of any navigation alternative.

While the benefits presented in this document will display the average values for the vessel operating cost model, further detail regarding the risk and uncertainty analysis is displayed in Section 9. Tables 91 and 92 display the estimated vessel operating costs for both bulk and container vessels.

[21] In the EGM 98-2 design drafts are related to a specific point estimate dwt.

Table 91. Estimated Foreign Flag Container Carrier Costs (1997 Price Levels)

Design Draft	DWT	TEU Capacity	Replacement Costs	Imm. Rate	Horse Power	Fixed Annual	Annual Capital	Total Annual	Total Daily	Fuel Main	Fuel Aux	Sea, Daily Fuel	Port, Daily Fuel	Total Daily Sea	Total Daily Port
46.00	82,000	6,000	112,525,308	246	68,872	3,573,110	10,725,005	14,298,115	40,852	188	4.00	21,022	785	61,874	41,637
45.00	76,667	5,600	100,830,678	234	65,915	3,337,948	9,610,367	12,948,316	36,995	181	4.00	20,211	785	57,206	37,780
44.00	71,333	5,200	89,136,049	223	62,957	3,102,787	8,495,730	11,598,516	33,139	173	4.00	19,396	785	52,535	33,924
43.00	66,000	4,800	77,441,419	211	60,000	2,867,625	7,381,092	10,248,717	29,282	165	4.00	18,580	785	47,862	30,067
42.00	55,000	4,000	74,634,708	186	45,567	2,811,187	7,113,579	9,924,766	28,356	128	4.00	14,552	785	42,908	29,142
41.00	49,000	3,500	70,424,641	171	40,388	2,726,529	6,712,309	9,438,838	26,968	114	3.50	12,988	687	39,956	27,655
40.00	45,500	3,250	66,916,252	163	37,367	2,655,981	6,377,918	9,033,898	25,811	106	3.50	12,128	687	37,939	26,498
39.00	42,000	3,000	63,407,863	154	34,346	2,585,432	6,043,526	8,628,958	24,654	98	3.50	11,263	687	35,917	25,341
38.00	39,000	2,800	60,601,152	146	31,757	2,528,994	5,776,013	8,305,007	23,729	91	3.50	10,517	687	34,246	24,416
37.00	35,000	2,500	52,181,019	136	28,305	2,359,677	4,973,474	7,333,151	20,952	82	3.00	9,418	589	30,370	21,541
36.00	33,000	2,350	50,054,649	131	26,578	2,322,684	4,770,806	7,093,489	20,267	77	3.00	8,915	589	29,182	20,856
35.00	31,000	2,200	47,928,279	125	24,852	2,285,690	4,568,137	6,853,827	19,582	73	3.00	8,409	589	27,992	20,171
34.00	28,000	2,000	41,549,168	116	22,263	2,174,708	3,960,132	6,134,840	17,528	66	3.00	7,647	589	25,175	18,117
33.00	25,500	1,800	39,422,798	109	20,105	2,137,714	3,757,464	5,895,178	16,843	60	2.75	6,957	540	23,801	17,383
32.00	23,000	1,600	37,296,428	101	17,947	2,100,720	3,554,795	5,655,515	16,159	54	2.50	6,263	491	22,422	16,649

Table 92. Estimated Foreign Flag Bulk Carrier Costs (1997 Price Levels)

Design Draft	DWT	Horse Power	Replacement Costs	Imm. Rate	Fixed Annual	Annual Capital	Total Annual	Total Daily	Fuel Main	Fuel Aux	Sea, Daily Fuel	Port, Daily Fuel	Total Daily Sea	Total Daily Port
49	100,000	15,731	42,011,628	212	2,017,025	4,004,210	6,021,234	17,453	47.2	3.0	5,665	589	23,117	18,042
48	91,933	15,076	39,754,548	200	1,945,904	3,789,083	5,734,987	16,623	45.3	3.0	5,463	589	22,086	17,212
47	83,867	14,422	37,497,469	189	1,874,784	3,573,956	5,448,740	15,793	43.4	3.0	5,261	589	21,054	16,382
46	75,800	13,767	35,240,389	177	1,803,663	3,358,830	5,162,493	14,964	41.5	3.0	5,058	589	20,022	15,553
45	71,900	13,451	34,149,157	171	1,769,279	3,254,822	5,024,101	14,563	40.6	2.9	4,935	564	19,498	15,127
44	68,200	13,150	33,113,885	166	1,736,657	3,156,148	4,892,806	14,182	39.8	2.8	4,818	540	19,000	14,722
43	66,600	13,021	32,666,199	164	1,722,551	3,113,478	4,836,029	14,017	39.4	2.6	4,753	515	18,770	14,533
42	63,600	12,777	31,826,790	160	1,696,101	3,033,473	4,729,574	13,709	38.7	2.5	4,653	491	18,362	14,200
41	59,900	12,477	30,973,042	156	1,665,749	2,952,100	4,617,849	13,385	37.8	2.5	4,559	491	17,944	13,876
40	57,300	12,266	30,448,790	151	1,648,431	2,902,133	4,550,564	13,190	37.2	2.5	4,494	491	17,684	13,681
39	43,400	11,139	27,646,062	124	1,555,851	2,635,000	4,190,851	12,147	33.9	2.5	4,142	491	16,289	12,638
38	42,000	11,025	27,363,772	121	1,546,526	2,608,094	4,154,621	12,042	33.6	2.5	4,106	491	16,149	12,533
37	39,400	10,814	26,839,521	116	1,529,209	2,558,127	4,087,336	11,847	33.0	2.5	4,040	491	15,887	12,338
36	37,200	10,635	26,395,924	112	1,514,556	2,515,847	4,030,403	11,682	32.5	2.3	3,935	442	15,617	12,124
35	34,150	10,388	25,780,936	106	1,494,242	2,457,231	3,951,473	11,454	31.7	2.0	3,808	393	15,262	11,846
34	31,100	10,141	25,165,949	100	1,473,927	2,398,616	3,872,543	11,225	31.0	2.0	3,731	393	14,955	11,617
33	28,050	9,893	24,550,962	94	1,453,613	2,340,000	3,793,613	10,996	30.3	2.0	3,653	393	14,649	11,389
32	25,000	9,646	23,935,975	88	1,433,299	2,281,384	3,714,683	10,767	29.6	2.0	3,575	393	14,342	11,160
31	23,000	9,483	23,532,704	84	1,419,978	2,242,948	3,662,926	10,617	29.1	1.9	3,504	373	14,121	10,990
30	21,000	9,321	23,129,434	80	1,406,657	2,204,511	3,611,168	10,467	28.6	1.8	3,434	353	13,901	10,820
29	19,000	9,159	22,726,164	76	1,393,336	2,166,075	3,559,411	10,317	28.2	1.7	3,363	334	13,680	10,651
28	17,000	8,997	22,322,893	72	1,380,015	2,127,639	3,507,653	10,167	27.7	1.6	3,292	314	13,459	10,481
27	15,000	8,834	21,919,623	68	1,366,694	2,089,202	3,455,896	10,017	27.2	1.5	3,221	294	13,238	10,312

7.2. Days at Sea and In Port

The number of days spent "at sea" and "in port" is an important component in the calculation of vessel transportation costs. The number of days at sea was calculated using the major destination points of each commodity. The calculation was made using the average speeds listed in the IWR vessel operating cost data. Bulk vessels were based on an average speed of 14 knots, while container vessels were based on an average speed of 19 knots. The *National Economic Development Procedures Manual for Deep Draft Navigation*, (IWR Report 91-R-13, November 1991), lists the trade route round trip distances which will be used in calculating vessel transportation costs. It should be noted that these distances include some voyage circuitry, to account for average effective speeds due to bad weather and course deviations for various reasons. It should also be noted that the distances used here reflect bulk and tanker distances, not liner distances. In scoping the analysis of transportation costs for container vessels, it was determined that the analysis would be simplified by assuming that the vessels go directly from the Columbia River to the destination port, without attempting to calculate costs by routing pattern, meaning that benefits are calculated on a one-way basis. The major trade route for wheat, corn, and container exports is the Pacific to the Far East, with a round trip distance of 11,500 miles. The major trade route for barley exports is from the Pacific to the area of India to the Red Sea, with a round trip distance of 21,500 miles. The major trade route for alumina imports is from Australia to the Pacific, with a round trip distance of 14,500 miles. The resulting number of days at sea for wheat and corn exports is 34 days; it is 64 days for barley; it is 25 days for containers; and, it is 43 days for alumina. Tables 93 through 98 summarize average days in the river, by vessel operating draft, by port, and by commodity. The average days were calculated based on data for the period 1991 through 1993.

Table 93. Columbia River Vessel Transits, Wheat 1991–1993, Kalama/Longview

Destination	Draft	Avg. Days in Transit	Number of Vessels
Kalama	29	5.1	9
Kalama	31	4.2	6
Kalama	32	10.6	9
Kalama	33	5.1	15
Kalama	34	7.1	25
Kalama	35	8.1	20
Kalama	36	10.1	16
Kalama	37	10.6	14
Kalama	38	8.9	13
Kalama	39	11.9	7
Kalama	40	5.4	6
Longview	32	7.7	1
Longview	33	14.2	1
Longview	34	6.7	2
Longview	35	9.5	1
Longview	39	11.4	1
Longview	40	3.0	1
Longview	41	10.6	1

Table 94. Columbia River Vessel Transits, Wheat 1991–1993, Portland/Vancouver

Destination	Draft	Average Days in Transit	Number of Vessels
Portland	29	4.4	19
Portland	30	9.1	11
Portland	31	5.6	20
Portland	32	6.7	43
Portland	33	8.3	86
Portland	34	6.9	124
Portland	35	8.1	112
Portland	36	9.1	85
Portland	37	8.5	73
Portland	38	9.3	45
Portland	39	9.7	50
Portland	40	8.5	14
Portland	41	10.2	6
Vancouver	29	6.7	22
Vancouver	30	5.8	11
Vancouver	31	7.0	12
Vancouver	32	8.6	32
Vancouver	33	7.2	63
Vancouver	34	7.0	73
Vancouver	35	8.7	77
Vancouver	36	8.2	52
Vancouver	37	8.6	43
Vancouver	38	6.9	26
Vancouver	39	10.3	22
Vancouver	40	8.3	6

Table 95. Columbia River Vessel Transits, Corn 199 -1993

Destination	Draft	Average Days in Transit	Number of Vessels
Kalama	29	5.6	7
Kalama	30	7.3	2
Kalama	32	3.2	3
Kalama	33	4.1	7
Kalama	34	8.1	8
Kalama	35	7.0	12
Kalama	36	7.4	30
Kalama	37	5.8	25
Kalama	38	3.2	3
Kalama	39	9.1	43
Kalama	40	8.2	95
Kalama	41	4.5	9
Portland	29	4.4	1
Portland	39	9.2	2
Portland	40	11.1	1

Table 96. Columbia River Vessel Transits, Barley 1991-1993

Destination	Draft	Average Days in Transit	Number of Vessels
Astoria	32	8.0	1
Kalama	35	13.8	1
Kalama	36	9.2	1
Longview	36	14.4	1
Portland	31	2.4	1
Portland	32	14.3	2
Portland	33	7.8	7
Portland	34	12.7	2
Portland	35	7.3	2
Portland	36	7.6	4
Portland	38	10.1	9
Portland	39	9.5	5

Table 97. Columbia River Vessel Transits, Alumina, 1991-1993

Destination	Draft	Average Days in Transit	Number of Vessels
Astoria	36	7.3	1
Kalama	34	13.9	2
Kalama	37	10.9	2
Longview	29	10.5	1
Longview	32	6.6	1
Longview	33	5.6	3
Longview	35	7.0	16
Longview	36	7.7	26
Longview	37	6.3	9
Portland	29	4.8	6
Portland	30	5.4	3
Portland	31	2.8	3
Portland	32	5.8	3
Portland	33	4.0	7
Portland	34	7.7	3
Portland	35	8.5	9
Portland	36	10.3	15
Portland	37	5.5	2
Portland	38	8.3	2
Vancouver	29	5.7	12
Vancouver	31	4.0	5
Vancouver	34	8.3	3
Vancouver	35	7.9	4
Vancouver	36	6.2	3
Vancouver	38	4.6	1

Table 98. Columbia River Vessel Transits, Container Vessels, 1991-1993

Draft	Average Days in Transit	Number of Vessels
29	1.1	47
30	1.2	39
31	1.3	48
32	1.5	102
33	1.5	103
34	1.4	126
35	1.5	85
36	1.4	37
37	1.4	19
38	2.2	7
39	1.4	1
40	0.4	1

The tables show that there is not a direct correlation between the number of days in the river and vessel draft. Actual practice does not demonstrate that there is necessarily an increase in days in the river associated with an increase in vessel draft. Consequently, an average number of days has been calculated from the preceding tables for each commodity, and will be used as representative of days in port in the calculation of single trip movement costs. For wheat, the average is 8 days; for corn, it is 8 days; for barley, it is 9 days; for containers, it is 1 day; and, for alumina, it is 7 days.

8. BENEFITS

The benefits of improving the navigation channel would result from reductions in transportation costs for each benefiting commodity. As shown in the fleet projections (Section 6), there are a number of vessels that load at less than their maximum capacity due to current channel depth constraints. For those vessels, a 3-foot deepening would essentially allow an increase in capacity of 6,000 to 7,400 tons.

For example, a bulk carrier with a 43-foot maximum draft typically has a maximum cargo capacity of approximately 60,000 tons. In a 40-foot channel, the capacity of this vessel is reduced to 54,000 tons. One-way vessel operating costs for a vessel carrying a load of wheat or corn out of the Columbia River average $750,000 per trip. Therefore, a 3-foot deepening can reduce transportation costs from $13.90 to $12.60 per ton, or $1.30 per ton.

As shown in the fleet projections, each commodity and trade route combination is expected to make varying use of the deepening. For wheat the additional three feet of channel depth will result in an average transportation cost-per-ton reduction of 4 to 5 percent, or a saving of $0.75 to $1.10 per ton. Corn is projected to take greater advantage of the deepening, with cost reductions averaging 6 to 8 percent, which typically amounts to $1.00 to $1.20 per ton. Container transportation benefits are slightly greater than for bulk commodities, with cost reductions averaging 11 to 13 percent, or $2.50 to almost $3.00 per ton.

Table 99 and Table 100 display examples of the calculation of transportation costs, showing costs for corn moving to countries in the Rapidly Developing Asia region in the year 2014 for both the without-project condition (no action alternative) and the 43-foot channel alternative. For each trade route and commodity, transportation costs are calculated over the period of analysis (2004 to 2054) and then annualized. In the without-project condition, 78 percent of the corn moving on this trade route is expected to move on vessels of design drafts greater than 40 feet. Over 7 million tons of corn are expected to move on this trade route, at an average cost per ton of $15.06. With an increase in channel depth, the transportation costs for this trade route drop to $14.07 per ton, resulting in a total reduction in costs of $3.5 million for that year. The average annual benefits for this trade route total $3,950,000.

Table 99. Without-Project, Corn Transportation Costs, Rapidly Developing Asia, 2014

Design Draft (feet)	Departure Draft	Tonnage Distribution	Total Tons	Per Ton Transportation Costs	Total Transportation Costs
36	36	7%	247,333	$19.53	4,831,051
37	37	8%	282,666	$18.35	5,186,703
38	38	7%	247,333	$17.63	4,359,286
39	39	---	---	$16.80	---
40	40	---	---	$16.40	---
41	40	4%	141,333	$13.96	1,973,300
42	40	14%	494,665	$14.04	6,945,734
43	40	25%	883,331	$13.98	12,352,834
44	40	21%	741,998	$14.13	10,482,294
45	40	10%	353,332	$14.47	5,113,671
46	40	4%	141,333	$14.01	1,979,942
Totals	---	100.00%	3,533,322	$15.06	$53,224,816

Table 100. 43-foot Alternative, Corn Transportation Costs, Rapidly Developing Asia, 2014

Design Draft (feet)	Departure Draft	Tonnage Distribution	Total Tons	Per Ton Transportation Costs	Total Transportation Costs
36	36	7%	247,333	$19.53	4,831,051
37	37	8%	282,666	$18.35	5,186,703
38	38	7%	247,333	$17.63	4,359,286
39	39		-	$16.80	-
40	40		-	$16.40	-
41	41	4%	141,333	$13.48	1,905,385
42	42	14%	494,665	$13.09	6,472,951
43	43	25%	883,331	$12.61	11,139,616
44	43	21%	741,998	$12.72	9,439,356
45	43	10%	353,332	$13.00	4,592,982
46	43	4%	141,333	$12.62	1,783,248
Totals		100.00%	3,533,322	$14.07	$49,710,578

Container benefits are calculated in a slightly more complex manner than are bulk commodity benefits. First, as shown earlier in the fleet projections and commodity projections, the container fleet has been divided into those vessels using the Columbia as a last port of call on the West Coast, and those vessels that visit at least one more West Coast port before sailing to an overseas destination.

For those container vessels that are using Portland as a last port of call, all tonnage on board the vessel is considered to benefit from the channel deepening, meaning that cargo loaded in Los Angeles might benefit from a Columbia River channel deepening if the Columbia is acting as the ultimate west coast draft constraint. Transportation benefits are only calculated for the one-way trip to the overseas destination. For vessels that use the Port of Portland as a mid-port of call, benefits are taken only for reducing transportation costs between Portland and the next West Coast port of call.

Also, for container vessels, an adjustment is made to the benefit calculation to account for the weight of the container and the weight of empties. Using 1993 actual vessel movements, it was estimated that Columbia River container vessels typically have an actual cargo capacity of approximately 70% of the dwt of the vessel. This adjustment is made to reflect that benefits are only calculated for actual cargo, rather than the weight of the containers themselves.

As an example of a container vessel movement, consider a 42-foot design draft, 55,000 dwt container vessel. This vessel would have a fully laden cargo capacity of 37,950 metric tons, excluding the typical weight of containers and empties. Using a typical last-port vessel trip, one-way voyage costs for this vessel total $587,000, assuming one day in port and thirteen days at sea. Using an immersion rate of 2,232 tons per foot, this vessel, moving at an operating draft of 36 feet, would have a light-loaded cargo capacity of 24,560, resulting in an average transportation cost of $23.90 per ton. If this same vessel was loaded to 39 feet, the vessel cargo capacity increases to 31,250 tons, reducing the average transportation cost to $18.78 per ton.

Table 101 displays the projected transportation costs for last-port container vessels in 2014. The average cost per ton is $22.33. In the 43-foot channel alternative, average transportation costs drop to $19.58 per ton, lowering transportation costs by almost $20 million.

Table 101. Without-Project, Container Transportation Costs, 2014

Design Draft	Typical Dwt	Combined Tonnage Distribution	Actual Tons	Average Transportation Cost per Ton	Total Transportation Costs
36	31,000	0%	-	-	-
37	33,000	1%	69,395	20.38	1,414,265
38	35,000	1%	69,395	21.62	1,500,607
39	35,000	22%	1,526,688	22.22	33,921,154
40	39,000	17%	1,179,713	22.54	26,596,382
41	42,000	13%	902,134	22.64	20,425,149
42	45,500	26%	1,804,267	22.58	40,741,125
43	49,000	13%	902,134	22.12	19,954,684
44	55,000	4%	277,580	20.85	5,786,680
45	66,000	3%	208,185	22.15	4,610,635
		100%	6,939,490	22.33	154,950,682

Table 102. 43-foot Alternative, Container Transportation Costs, 2014

Design Draft	Typical Dwt	Combined Tonnage Distribution	Actual Tons	Average Transportation Cost per Ton	Total Transportation Costs
36	31,000	0%	-	-	-
37	33,000	1%	69,395	20.38	1,414,265
38	35,000	1%	69,395	19.93	1,383,351
39	35,000	22%	1,526,688	20.39	31,134,892
40	39,000	17%	1,179,713	19.96	23,547,842
41	42,000	13%	902,134	19.34	17,445,694
42	45,500	26%	1,804,267	19.63	35,418,133
43	49,000	13%	902,134	19.08	17,212,777
44	55,000	4%	277,580	16.78	4,657,407
45	66,000	3%	208,185	17.72	3,688,656
		100%	6,939,490	19.58	135,903,018

Table 103 displays the average annual transportation benefits for the 43-foot channel alternative by commodity and trade route. The annual benefits for this alternative total almost $38.7 million. Container traffic provides approximately 60 percent of the benefits of this alternative, with corn and wheat benefits making up the majority of the remainder.

Table 103. Average Annual Transportation Benefits, 43-foot Alternative

Commodity	Rapidly Developing Asia	Japan	China	Other	Other Asia	All	Totals
Corn	3,946,000	672,000	956,000				5,574,000
Wheat	2,558,000			1,620,000	4,236,000		8,414,000
Barley						1,096,000	1,096,000
Containers – Mid Port						1,431,000	1,431,000
Containers – Last Port						22,183,000	22,183,000
Totals	6,504,000	672,000	956,000	1,620,000		24,710,000	38,698,000

8.1. Incremental Analysis

Incrementally, the 43-foot channel alternative is justified both by channel depth and river reach. Since the smallest logical increment in which to analyze channel depths is a foot, channel depths of 41 feet and 42 feet are also addressed. The fleets and commodity projections for each increment of channel depth are identical except for the expected departure draft of those vessels constrained by the depth of the channel. Table 104 displays the calculation for the 42-foot increment. As compared to the transportation costs for the same trade route (Table 100), the incremental benefits (reduction in transportation costs) for the 43-foot channel relative to the 42-channel are approximately $0.9 million in the year 2014. This difference is due to the lower per-ton costs of those vessels expected to be constrained by a 42-foot channel.

Table 104. 42-foot Alternative, Corn Transportation Costs, Rapidly Developing Asia, 2014

Design Draft (feet)	Departure Draft	Tonnage Distribution	Total Tons	Per Ton Transportation Costs	Total Transportation Costs
36	36	7%	247,333	$19.53	4,831,051
37	37	8%	282,666	$18.35	5,186,703
38	38	7%	247,333	$17.63	4,359,286
39	39	---	---	$16.80	---
40	40	---	---	$16.40	---
41	41	4%	141,333	$13.48	1,905,385
42	42	14%	494,665	$13.09	6,472,951
43	42	25%	883,331	$13.04	11,516,647
44	42	21%	741,998	$13.16	9,763,152
45	42	10%	353,332	$13.46	4,754,349
46	42	4%	141,333	$13.05	1,844,322
Totals	---	100.00%	3,533,322	$14.33	$50,633,846

The channel can be divided into three reaches. The first reach stretches from the mouth of the Columbia to Kalama, where the majority of corn benefits and some wheat benefits are realized. The channel from Kalama to the confluence of the Willamette River and the Columbia River is the second reach, where the container benefits are realized. The third reach consists of the Willamette River, in which more than half of the wheat and barley benefits are realized. For each commodity, historical exports have been used to determine the share of benefits allocated to each reach as displayed in Table 105. Table 106 displays the total transportation and delay benefits by channel depth and reach.

Table 105. Allocation of Benefits by Reach

Commodity	Mouth to Kalama/Longview	Kalama/Longview to Willamette	Willamette
Corn	95%	0	5%
Wheat	8%	35%	57%
Barley	20%	5%	75%
Mid-Port Reach	0	100%	0
Last Port Reach	0	100%	0

Table 106. Incremental Transportation and Delay Benefits

Incremental Depths (feet)	Mouth to Kalama/Longview	Kalama/Longview to Willamette	Willamette	Total
41	$2,368,000	$9,205,000	$2,620,000	$14,193,000
42	$2,119,000	$9,267,000	$2,111,000	$13,497,000
43	$1,627,000	$8,505,000	$1,316,000	$11,448,000
Totals	$6,114,000	$26,977,000	$6,047,000	$39,138,000

As seen in Table 106, the incremental average annual benefits for the first foot of channel deepening are the highest, at $14.2 million. The incremental benefits of the second foot of deepening are slightly less but amount to an additional $13.5 million. For the third foot of deepening, the incremental average annual benefits are an additional $11.4 million. The average annual benefits of the 43-foot channel alternative total over $39 million.

8.2. Costs and Net Benefits

The following tables display the costs and benefits of the channel improvement alternatives. Table 107 displays the NED costs of the channel improvement alternatives. These costs include all costs required in order to achieve the benefits of the navigation channel, including removal and replacement of utilities and the deepening of berthing areas.

Table 107. Channel Deepening NED Costs

First Costs	41' Channel	42' Channel	43' Channel	Non-Structural
Construction	44,968,500	81,625,700	151,358,000	500,000
Utilities	16,262,000	16,262,000	16,262,000	-
Berthing Areas	400,000	800,000	1,200,000	400,000
IDC	3,616,000	6,564,000	12,171,000	
Total First Costs	65,246,500	105,251,700	180,991,000	900,000
Annualized First Costs	$4,803,000	$7,747,000	$13,322,000	$66,000
Annual Maintenance Costs				
Channel Maintenance	902,000	1,998,000	3,600,000	-
Mitigation Site Maintenance	250,000	250,000	250,000	-
O&M Real Estate	46,000	46,000	46,000	-
Total Annual Maintenance Costs	1,198,000	2,294,000	3,896,000	100,000
Total Costs, Average Annual	$6,001,000	$10,041,000	$17,218,000	$166,000

Table 108 displays the net benefits of the four channel improvement alternatives. As can be seen in the table, net benefits are increasing for each alternative, resulting in the 43-foot channel having the greatest net benefits, at approximately $22.2 million[22].

Table 108. Net Benefits

	41' Channel	42' Channel	43' Channel	Non-Structural
Total Costs, Average Annual	$6,001,000	$10,041,000	$17,218,000	$166,000
Benefits	$14,193,000	$27,690,000	$39,412,000	$4,223,000
Net Benefits	$8,192,000	$17,649,000	$22,194,000	$4,057,000
BCR	2.37	2.76	2.29	25.44

Additionally, each reasonable increment of the 43-foot channel has been analyzed. Table 109 displays the costs and benefits associated with each incremental reach of the navigation channel. The first reach of the navigation channel, from the mouth of the Columbia to Kalama, does not produce enough benefits to support the deepening of that reach. The first reach is only viable when continuing the deepening to at least the Port of Portland, from which the majority of the navigation benefits are achieved. The final reach of the navigation channel, the Willamette reach, provides incremental benefits that are more than double the incremental costs of deepening that reach.

[22] Costs and benefits have been adjusted to reflect that the first reach of the navigation channel, from the mouth to Kalama, will be completed one year prior to the base year.

Table 109. Incremental Reach Analysis

First Costs	Mouth to Kalama	Kalama to Willamette	Willamette
Construction	82,832,000	46,913,000	21,614,000
Utilities	1,815,000	3,634,000	10,813,000
Berthing Areas	250,000	490,000	460,000
Total First Costs	84,897,000	51,037,000	32,887,000
Annualized First Costs	$6,249,000	$3,757,000	$2,421,000
Annual Maintenance Costs			
Channel Maintenance	2,140,000	1,460,000	-
Mitigation Site Maintenance	137,000	77,000	36,000
O&M Real Estate	37,000	9,000	-
Total Annual Maintenance Costs	2,314,000	1,546,000	36,000
Total Costs, Average Annual	$8,563,000	$5,303,000	$2,457,000
Benefits	$6,114,000	$26,977,000	$6,047,000
Net Benefits	$(2,449,000)	$21,674,000	$3,590,000
BCR	0.71	5.09	2.46

8.3. Delay Benefits

Many of the deep draft vessels on the Columbia depart at depths of 38 feet or greater. With underkeel clearance, this typically means that, in a forty-foot channel, pilots use tides to transit the 107 miles from Portland to the mouth safely, incurring small amounts of delay. Thus, with a channel deepening, there is possibility of reducing those delays, however, given that many of the vessels which are maximizing their use of the 40-foot channel are also expected to maximize their utilization of a 43-foot channel, delay reductions are not great.

Table 110 displays the average delay per vessel by departure draft. For example a vessel departing at 40 feet in a 40-foot channel will typically delay 5.1 hours for an appropriate tide. A vessel departing at 37 feet or less will experience no delays due to draft. These tidal delays are expected to remain the same in any given deepening alternative. Therefore, in a 43-foot channel, a vessel departing at 43 feet will typically incur a 5.1-hour delay. Additional details regarding delay and tidal influences is located in Appendix A, *Engineering*.

Table 110. Average Delay Per Vessel by Draft Below Channel Depth

Feet Below Channel Depth	Hours of Delay
0	5.1
1	1.2
2	0.2
3+	0

The costs of incurring a delay, especially for bulk carriers, is extremely low relative to the value of adding additional cargo on board. For example, a corn-carrying bulk vessel of 40-foot design draft departing at the channel depth has an average transportation cost of approximately $14.50 per ton. Such a vessel typically incurs $0.075 per ton in delay costs (5.1 hours of in-port vessel operating costs). The value of departing at the channel depth, rather than an unconstrained draft of 37 feet or less, is substantial. If this same 40-foot design draft vessel had departed at 37 feet, it would have carried over 5,000 short tons less cargo, increasing transportation costs to $16.20 per ton. Thus, most bulk operators see substantial benefit in carrying as much cargo as possible, regardless of potential delays.

Container vessels generally operate on a schedule which does not allow for unexpected delays, thus, most (but not all) carriers operate using an underkeel clearance directly related to the authorized channel depth, rather than take chances on tidal variations.

Table 111 displays the incremental average annual delay benefits by commodity and channel depth. More than half of the delay benefits are achieved by wheat vessels, which occurs due to the large number of vessels for that commodity which have design drafts between 40 and 42 feet. Corn vessels show less delay reduction benefit due to their tendency to move at the channel constraint of all alternatives. The total average-annual delay-reduction benefit for the 43-foot channel is $439,000, or approximately 1.15 percent of the total benefits.

Table 111. Incremental Average Annual Delay Benefits by Channel Depth

Incremental Depths	Corn	Wheat	Barley	Containers - Last Port	Total
41 feet	13,000	26,000	-	70,000	109,000
42 feet	16,000	79,000	5,000	30,000	130,000
43 feet	46,000	134,000	7,000	13,000	200,000
Total	$75,000	$239,000	$12,000	$113,000	$439,000

8.4. Turning Basins

As a part of the analysis of the navigation channel, each of the turning basins on the Columbia has been evaluated in terms of adequacy of dimension and usefulness. In cases where the existing turning basins will be deepened the depth of the turning basin will be commensurate with each channel-deepening alternative. The evaluation on which turning basins to modify is based on current operating practices in which vessels, for safety and control reasons, are typically turned only after loading has been completed.

Beginning at the mouth of the Columbia and moving upstream, the first turning basin is located near Astoria at CRM 15. This turning basin is approximately 800 feet wide and 4,250 feet long. This turning basin is located in an area of the river that has been dredged to depths greater than 50 feet to provide fill for land development purposes, thus no new work will be required under any alternatives.

The next turning basin is located at Longview at CRM 66.5. This turning basin is 1,200 feet wide and 5,500 feet long, and will remain at a depth of 40 feet in all alternative conditions. Currently, no commodities requiring vessel drafts greater than 40 feet are being shipped through Longview. If this situation changes, then the turning basin will be reconsidered in terms of adequacy of depth, width, and length.

The next turning basin on the Columbia is located at Kalama near CRM 73.5. This basin is approximately 700 feet wide and 4,100 feet long. This turning basin will be deepened, but is otherwise considered to be of adequate dimensions. This turning basin services two grain facilities, one of which is the primary corn exporting terminal on the Columbia. In order to achieve the benefits of the channel deepening associated with the corn and wheat exports at Kalama, this turning basin will need to be deepened. The cost of the deepening the turning basin is $230,000. As there are no other turning options near this location, the benefits of the turning basin are also the benefits of deepening the channel for this reach, approximately $6.1 million on average annual basis.

There are two turning basins adjacent to the Vancouver docks. The upper turning basin, at approximately RM 107, has an existing depth of 35 feet, and will not be considered for deepening, as it primarily services vessels that do not require deeper depths.

The lower Vancouver turning basin at about CRM 105.5 is 3,000 feet long and 1,000 feet wide. This turning basin services the United Grain facility, which typically handles 35 percent of Columbia River wheat exports. In 1993, this terminal loaded almost 4.5 million short tons of wheat on 160 vessels. If this turning basin is not deepened, it is possible that vessels could be backed down the river to the confluence of the Willamette and Columbia, which is approximately three miles downstream. The river pilots have indicated that this option raises serious safety concerns relating to the number of vessels that are typically anchored outside the navigation channel in this reach of the river. Vessels backing down the river will require the use of three tugs (at $2,520 per hour each) to turn and back the vessel down the river, taking an additional hour (and an additional tug) to completely turn the vessel. Thus, the additional cost of backing a vessel down the river is at least $11,300 per vessel[23].

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[23] The $11,300 includes approximately $600 for one hour of deep draft vessel in-port operating costs, but does not include any costs to account for additional navigational risks.

In 1993, 24 out of a total of 160 vessels departed the United Grain terminal at a draft of 38 feet or greater. Assuming this number is representative of the number of vessels that would immediately take advantage of future deepening actions, the total average annual benefits of this turning basin would likely be greater than $270,000 on an average annual basis, or $3.7 million in net present value terms, which is far greater than the estimated costs of deepening the turning basin. Therefore this turning basin will be deepened.

The Willamette reach of the navigation channel is 11.6 miles long. For much of this reach, the navigation channel has been defined as being bank to bank. Due to concerns regarding rock, potential contaminants, and overall costs, the navigation channel in the Willamette reach will be narrowed in all deepening alternatives. Three authorized turning basins will occur in the 11.6 miles.

The first turning basin, moving upstream from the confluence of the Willamette and Columbia rivers, is located near WRM 4, adjacent to the Port of Portland's Terminal 4, a grain export facility, and will be deepened to facilitate deep draft grain vessels. If this turning basin is not deepened, then vessels will likely need to be backed four miles down the river to the confluence of the Willamette and Columbia rivers. Again, there are substantial costs involved with backing a vessel down the river, and, as with the lower Vancouver turning basin, the costs per vessel would amount to at least $11,300. At Terminal 4, in 1993, 11 out of 55 vessels left at depths greater than or equal to 38 feet. Assuming, for the purposes of this analysis, that this reflects the number of vessels which would immediately take advantage of a deeper channel, the benefits of deepening this turning basin amount to at least $125,000 on an average annual basis, or $1.7 million in net present value terms.

The second turning basin is located at WRM 10, adjacent to Port of Portland's Terminal 2, a general cargo facility. This turning basin will be designated as deepened, although, due to past mining activities, actual dredging work is expected to be minimal.

The last turning basin on the Willamette is also the only new designation on the entire navigation channel. This turning basin, located at WRM 11.7, will benefit the deep draft traffic at both the Cargil grain facility at WRM 11.2 and the Louis Dreyfus facility at WRM 12. While it is possible for large grain-carrying vessels to back down the river to the turning basin at WRM 10, there are substantial costs associated with that option.

Without this turning basin, vessels drafting greater than 40 feet will require the use of three tugs (at $2,520 per hour each) to turn and back the vessel down the river to WRM 10, taking 2.25 hours to completely turn the vessel. With a turning basin at WRM 11.7, each vessel can be turned using two tugs, taking only 1.25 hours to turn the vessel. Therefore, the additional cost of backing a vessel down the river is approximately $11,300 per vessel.

In 1993, 22 vessels departed the two grain terminals serviced by this turning basin at a draft of 38 feet or greater (out of a total of 83 vessels). Assuming this is representative of the proportion of vessels that would likely take advantage of future deepening actions, the total average annual benefits of this turning basin would likely be greater than $250,000 on an average annual basis, or $3.4 million in net present value terms, which is far greater than the estimated costs of constructing the turning basin.

Table 112 displays each of the turning basins (existing and proposed) on the navigation channel, indicating if the turning basin will be deepened in any deepening alternatives. The table also displays the quantity of material that will be removed in such cases.

Table 112. Turning Basins, Columbia River Deep Draft Navigation Channel

Turning Basin	Existing Dimensions	Deepened	Quantity	Cost
CRM 15	800 x 4,250	y	90,000	$285,000
CRM 66.5	1,200 x 5,500	n		
CRM 73.5	700 x 4,100	y	65,000	$230,000
CRM 105.5	1,000 x 3,000	y	285,000	$405,000
CRM 107		n		
WRM 4	5,000 x 1,000	y	15,000	$35,000
WRM 10	1,500 x 1,000	y	100,000	$125,000
WRM 11.7	1,500 x 1,000	y	80,000	$100,000

8.5. Anchorages

There are two Corps designated anchorages (one for shallow draft traffic, one for deep draft traffic) along the navigation channel, both of which are located at approximately CRM 103. The deep draft anchorage will be designated as being deepened in all deepening alternatives, although due to natural depths and mining, construction dredging will be minimal. The other anchorage has an authorized depth of 25 feet, which will not be altered in any of the study alternatives.

8.6. Berths

In order to achieve the benefits of any channel-deepening alternative, docks at each of the container, wheat, corn, and barley exporting facilities must be deepened. These costs have been included as part of the NED cost estimate, but are not part of the federal cost-sharing equation. Table 113 displays the costs of deepening at the eight facilities that must be deepened.

Table 113. Columbia River Deep Draft Berths Deepening Costs

Terminal	Cost
Harvest States in Kalama	250,000
Peavy in Kalama	-
United Grain in Vancouver	-
Terminal 6 - Containers, in Portland	490,000
Columbia Grain in Portland	39,400
Cargil Grain (Berth 401) in Portland	419,000
Irving Street Terminal, Cargil, in Portland	-
Louis Dreyfus Corp. in Portland	-
	$1,198,400

9. RISK AND UNCERTAINTY

All of the components of the analysis introduce some elements of uncertainty. The vessel operating costs, commodity projections, and fleet projections are all best estimates of what will come in the future, but are not certainties. This section addresses the primary areas of uncertainty, and presents a few break-even scenarios in order to demonstrate the conditions that would have to develop in order to change the recommended plan.

9.1. Commodity Projections

The risk and uncertainty analysis for the commodity projections is presented to allow decision-makers to see the range of likely tonnages for each commodity. The commodities used in the project's benefit calculations, wheat, corn, barley, and containers, were analyzed to establish a maximum and minimum range around the most likely estimate. This range captures a number of issues that create uncertainty in the most likely estimates used in the benefit calculations. The risk and uncertainty in the commodity projections is captured with a triangular distribution including maximum, minimum, and most likely estimates. A triangular distribution is applicable when an analyst has little statistical information regarding the variables. The most likely estimate is the forecasted value that Faucett (1996) derived using both econometric models and expert knowledge of the commodities. The statistical data from these models was not available so a more subjective process was used in creating the maximum and minimum estimates.

The process for establishing the maximum and minimum range for corn, wheat, and containers included analyzing the historical data, the knowledge of the analyst, and the trends of most likely estimates. The maximums and minimums are developed to address the lack of historical data about certain commodity movements on the Columbia and the increasing uncertainty of commodity forecasts into the future. The maximum and minimum estimates for barley employed a simplified method because barley tonnage is relatively small component of the project's benefits.

The first factor influencing the maximum and minimum estimates is the basic trends developed during the more detailed Faucett (1996) analysis. The analyst felt the basic trends would apply to the maximum and minimum to a larger or smaller extent. The next factor influencing the maximum and minimum forecasts is the increasing uncertainty as projections extended into the future. For example, in the 1962 study authorizing the current 40-foot channel depth, the difference between the actual and projected wheat tonnage in 1965 was only 300,000 tons. While, the 1995 projection for wheat under estimated actual tonnage by 7.2 million. This demonstrates the fact that predictions of next year's tonnage are more likely to be accurate than predictions fifty years in the future. In response to this issue, the maximum and minimum estimates tend to be close to the most likely estimate in the early years and increasingly diverge from the most likely as the projections extend into the future. This creates the funnel shape seen on the risk and uncertainty Figures 12 through 14.

The final factor the analyst employed in developing the maximum and minimum range for each commodity was to analyze the historical data. This analysis considered the volume, variance, and number of years that each commodity has moved on the Columbia River System. Corn is a commodity with a short and erratic history. Corn was not transported in significant quantities until 1984 and since then, tonnages have varied widely. For example, corn tonnages fell by nearly 5 million tons between 1989 and 1994 and then increased over 6 million tons from 1994 to 1995. In contrast to corn, wheat has a relatively long and steady history on the Columbia. Wheat tonnage is usually at least twice as high as corn tonnage each year. Also, wheat's variability has never been as large in absolute or percentage terms. Container traffic is relatively new to the system but during this time the trend has been towards steady growth. Corn's brief and varied history requires a wider range of tonnages around the most likely projection to capture the potential outcomes. Wheat's longer and steadier history results in smaller range around the most likely projection. While Container's short but steady history leads to a range in between the corn and wheat extremes.

To further examine the historical variance of corn, wheat, and containers a simple regression was performed with time as the independent variable and commodity tonnage as the dependent variable. These calculations supported the conclusions drawn in the previous section that over time wheat and containers have grown steadily compared to corn's erratic history. These regressions also calculated 95 percent confidence intervals for each commodity. The confidence intervals provide an indication of the reasonableness of the maximum and minimum estimates. The results were that the 95 percent confidence interval for corn was twice as wide as wheat's in 2004 and four times as wide by the year 2054. The lower end of the confidence interval for corn is zero tons for all years forecasted. These historical factors contribute to the wide maximum and minimum estimates for the corn forecast. After developing the maximum and minimum estimates, the analyst applied knowledge to further evaluate these projections. The maximum and minimum forecasts for wheat and container traffic are evenly spaced around the most likely estimate. This is likely due to an equal chance of tonnages varying above or below the most likely projections. The maximum estimate for the corn projection is twice as wide as the minimum estimate for corn. This demonstrates the belief that there is more likelihood of China and Rapidly Developing Asia increasing imports over the projected levels than falling short of the projected levels. Figures 12 through 14 illustrate the maximum, minimum, and most likely estimates for corn, wheat, and container tonnages.

Figure 12. Corn Commodity Projection Risk and Uncertainty

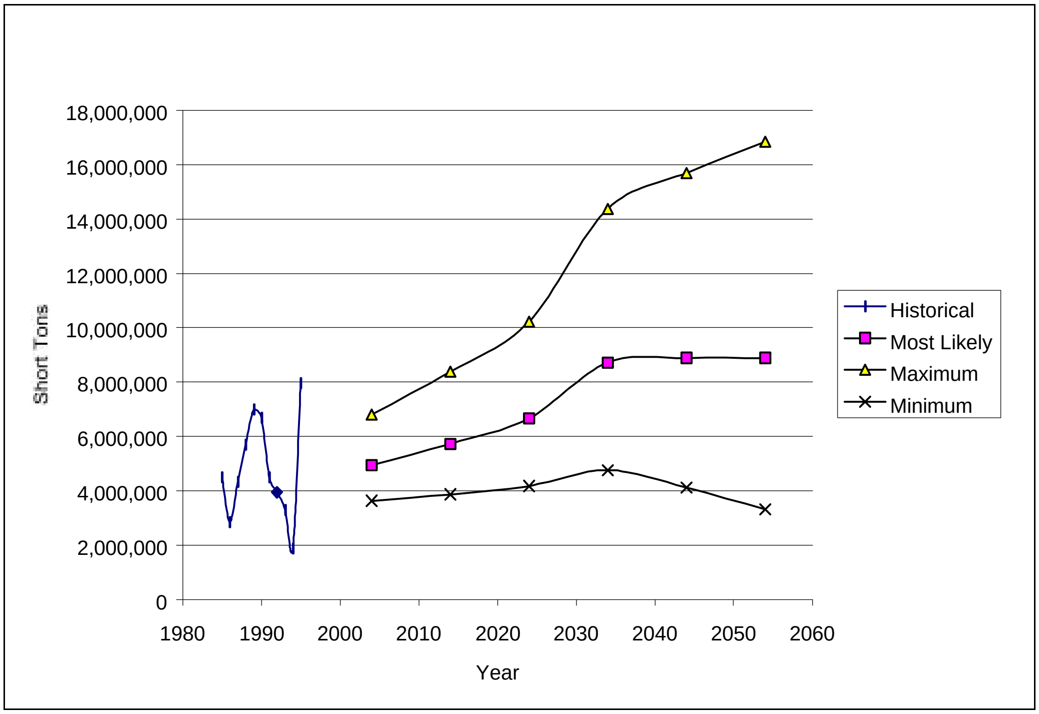


Figure 13. Wheat Commodity Risk and Uncertainty

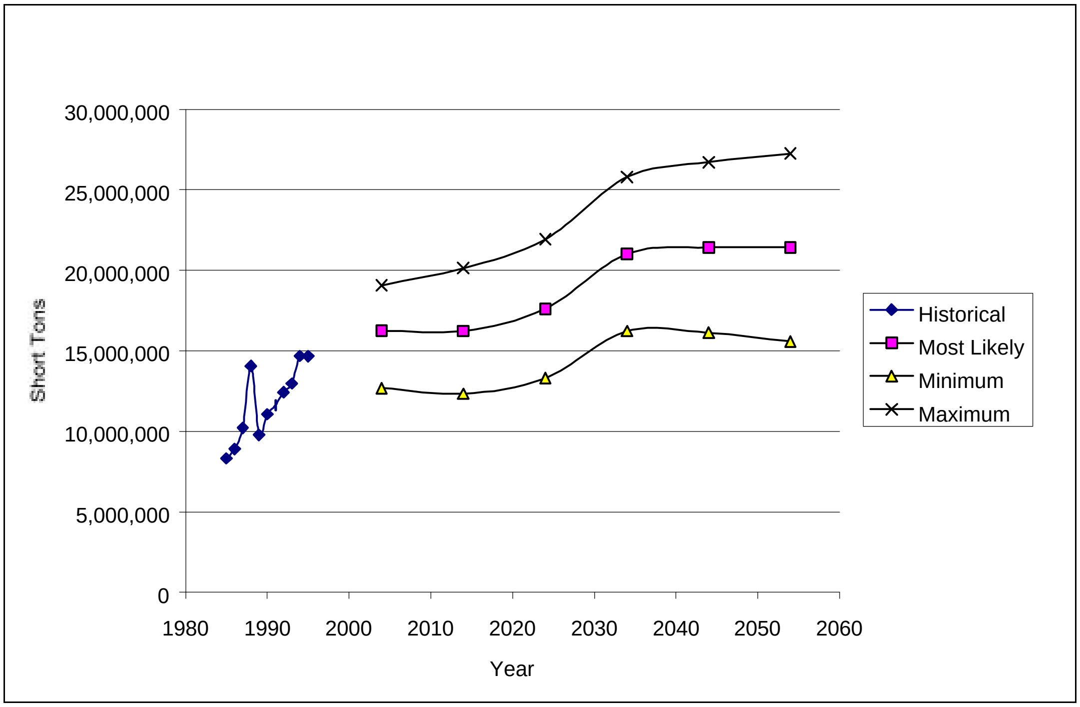
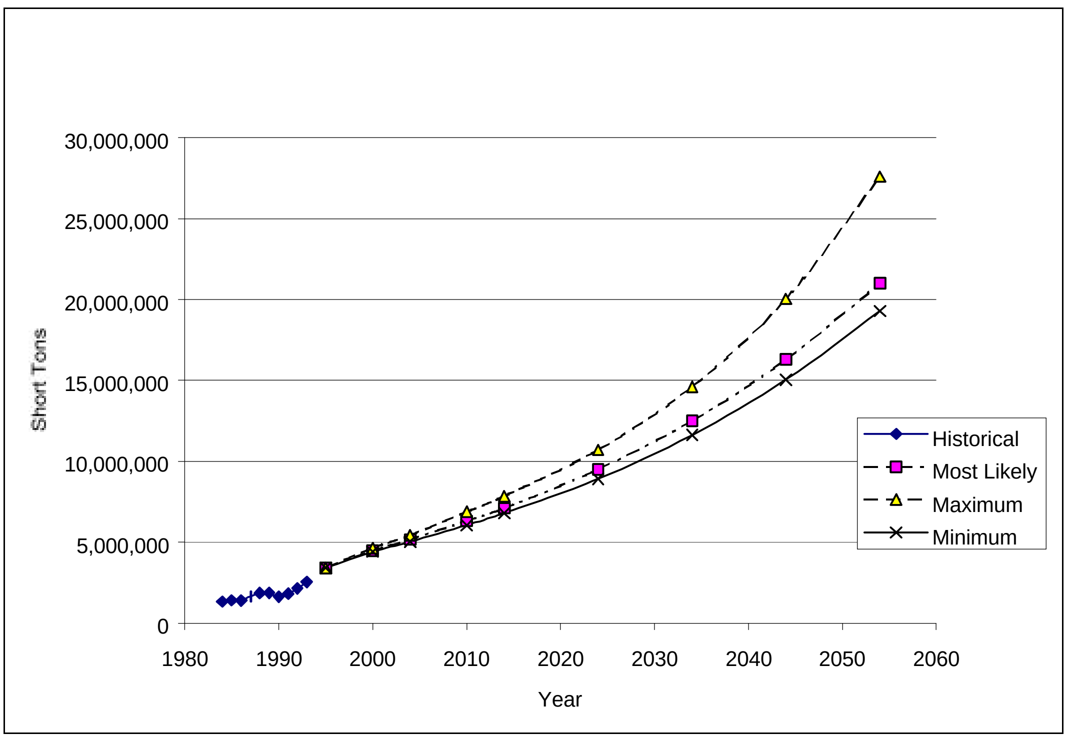
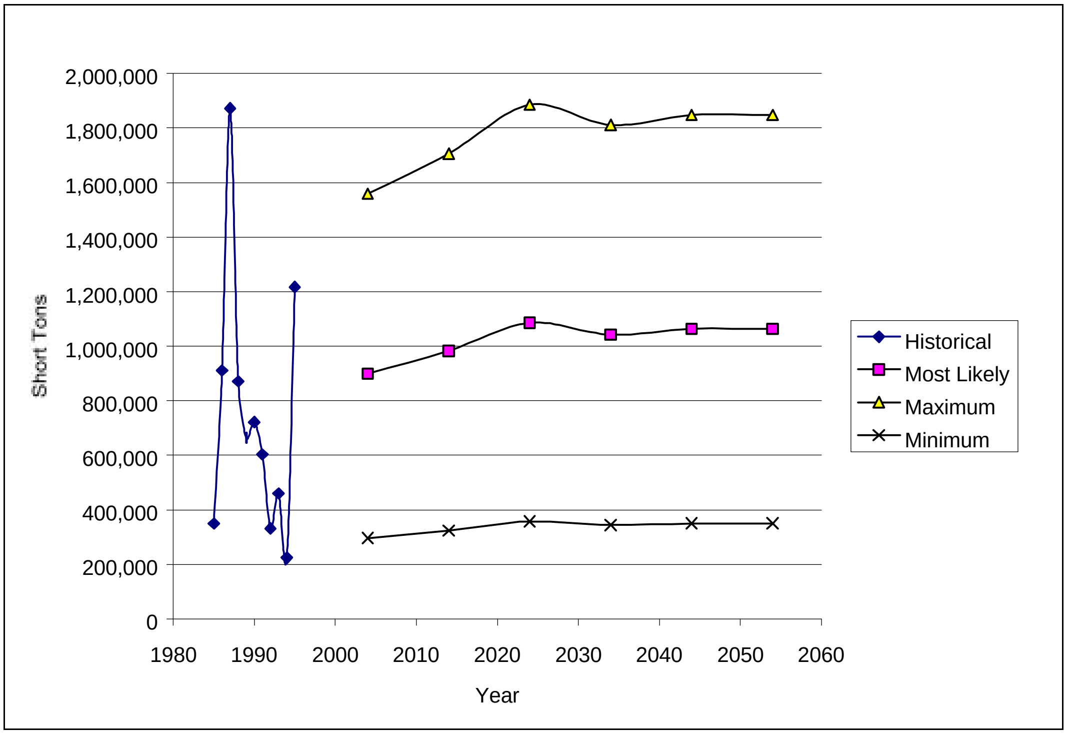


Figure 14. Container Commodity Risk and Uncertainty



For Barley a simplified analysis was performed. Barley tonnage is less significant for the benefit calculations with tonnage forecasted to stay at one million tons throughout the study period (2004-2054). In addition, the historical data shows that tonnages have varied widely for such small quantities. To estimate the maximum and minimum the recent historical high and low tonnages were used to define the starting points. The minimum estimates begin with the tonnage transported during 1994 and grow at the same rate as projected for the most likely estimate. The maximum started at the tonnage transported in 1995 and grows at the projected growth rate. This resulted in a rather wide band around the most likely estimate. Such a wide range of maximum and minimum estimates appears to fairly capture the uncertainty of this projection. Figure 15 shows the barley maximum, minimum, and most likely estimate.

Figure 15. Barley Commodity Risk and Uncertainty



Using these values in a Monte Carlo simulation shows the range of benefits that are possible given the assumptions of the risk analysis. Tables 114 through 117 display the range of benefits for each commodity, combining the distributions of commodity movements with the distributions described in the vessel operating cost discussion. For each benefit, the exceedance values are displayed, showing for example, that only 5 percent of the simulations resulted in container transportation benefits being less than $20.5 million.

Table 114. Distribution of Average Annual Container Transportation Benefits

Minimum =	20,175,950
Maximum =	22,494,770
Mean =	21,137,390
Mode =	21,355,910
5% Perc =	20,569,580
10% Perc =	20,677,190
15% Perc =	20,749,090
20% Perc =	20,816,040
25% Perc =	20,905,220
30% Perc =	20,960,950
35% Perc =	21,000,440
40% Perc =	21,042,450
45% Perc =	21,085,420
50% Perc =	21,128,280
55% Perc =	21,166,360
60% Perc =	21,217,030
65% Perc =	21,264,420
70% Perc =	21,317,410
75% Perc =	21,363,860
80% Perc =	21,433,620
85% Perc =	21,523,410
90% Perc =	21,600,950
95% Perc =	21,728,590

Table 115. Distribution of Average Annual Wheat Transportation Benefits

Minimum =	6,987,918
Maximum =	10,661,540
Mean =	8,483,842
Mode =	8,372,392
5% Perc =	7,592,027
10% Perc =	7,837,206
15% Perc =	7,958,385
20% Perc =	8,033,166
25% Perc =	8,113,433
30% Perc =	8,185,533
35% Perc =	8,279,225
40% Perc =	8,347,154
45% Perc =	8,416,762
50% Perc =	8,465,942
55% Perc =	8,533,768
60% Perc =	8,601,873
65% Perc =	8,687,037
70% Perc =	8,741,931
75% Perc =	8,813,962
80% Perc =	8,923,640
85% Perc =	9,041,333
90% Perc =	9,202,349
95% Perc =	9,318,897

Table 116. Distribution of Average Annual Corn Transportation Benefits

Minimum =	4,539,883
Maximum =	7,212,286
Mean =	5,609,040
Mode =	5,909,639
5% Perc =	4,829,899
10% Perc =	4,971,151
15% Perc =	5,128,722
20% Perc =	5,195,204
25% Perc =	5,271,681
30% Perc =	5,339,535
35% Perc =	5,423,131
40% Perc =	5,495,535
45% Perc =	5,549,776
50% Perc =	5,585,058
55% Perc =	5,632,727
60% Perc =	5,697,042
65% Perc =	5,763,070
70% Perc =	5,846,246
75% Perc =	5,925,835
80% Perc =	6,027,685
85% Perc =	6,114,250
90% Perc =	6,232,877
95% Perc =	6,415,580

Table 117. Distribution of Average Annual Barley Transportation Benefits

Minimum =	7,531,070
Maximum =	9,417,730
Mean =	8,499,335
Mode =	8,416,900
5% Perc =	7,697,675
10% Perc =	7,966,206
15% Perc =	8,025,065
20% Perc =	8,073,696
25% Perc =	8,168,674
30% Perc =	8,226,950
35% Perc =	8,307,327
40% Perc =	8,372,708
45% Perc =	8,414,139
50% Perc =	8,434,941
55% Perc =	8,556,192
60% Perc =	8,599,328
65% Perc =	8,693,460
70% Perc =	8,769,445
75% Perc =	8,824,178
80% Perc =	8,908,506
85% Perc =	9,002,996
90% Perc =	9,082,312
95% Perc =	9,251,565

Forecasting is an imperfect science and risk and uncertainty analysis is an attempt to capture these concerns. The maximum and minimum estimates are developed to acknowledge a number of issues that contribute to the uncertainty of any projection made into the future. The range of the maximum and minimum estimates suggests the relative uncertainty regarding each projection. As this analysis suggests, the corn and barley projections are made with a greater degree of uncertainty than the wheat and container projections.

While it was not possible, due to the amount of data necessary to calculate benefits, to run a Monte Carlo simulation of the total transportation benefits for the 43-foot channel, it is clear that the lowest end of each distribution of benefits would still combine to allow for considerable benefits for the project, even assuming that all commodities produced benefits at the low end of their individual estimates.

9.2. Breakeven Analysis

Another useful tool in evaluating the robustness of the benefits is a breakeven analysis. For this project, it is clear that the benefits far outweigh the costs. However, it can still be useful to examine the conditions under which deepening would not be justified.

The average annual benefits of the 43-foot channel are approximately $37.6 million. The average annual costs total approximately $17.5 million[24]. For this analysis, it is prudent to examine those scenarios that could reduce benefits by $20 million, slightly more than half the total benefits.

Table 118 displays an example of a scenario that would result in the benefits of a three-foot deepening being slightly less than the costs. In this scenario, the benefits for each commodity have been reduced, representing both the potential that less commodity will be shipped and the potential that vessels will not take advantage of a deeper channel. For each commodity, the probability of this scenario is remote.

Corn benefits, in this example, have been reduced by 50 percent. As discussed in Section 6.2.2 (the corn fleet projection) the existing corn fleet already contains a large number of vessels which could take advantage of a deeper channel immediately. The other portion of the risk revolves around the quantity exported, which has shown considerable variance over the last decade. It is possible, but difficult to predict with any certainty, that the current Asian currency crisis will result in short-term reductions in exports. However, it is also likely that this currency crisis will be a vague memory by the middle of the next decade. Assuming that the correlation between economic development and meat consumption continues through the next decade, it is highly unlikely that annual corn exports from the Columbia will be reduced by 50 percent.

Wheat benefits in this scenario are reduced by 25 percent. The risk of reduction appears to be more remote than for most other commodities. The history of Columbia River wheat exports is long, and the volumes are relatively consistent from year to year. Although the current Asian currency crisis will likely result in short-term quantity reductions, this is not expected to represent a long-term change in world wheat trade. Also, this analysis has assumed that the Japanese trade will remain in small lots, taking no benefit for a deeper channel. While there has been little evidence that this practice will change in the near future, the potential for an increase in wheat benefits is substantial.

[24] Not final costs.

Barley benefits are one of the smallest benefiting commodities, representing the fewest number of vessel trips. It is also the most difficult to predict, with few discernable trends. At this point, it appears that benefits are just as likely to double as they are to diminish by 50 percent, and the projection as described Section 5.1.4 remains the most likely scenario.

Containers are the largest of all benefit categories, and, in this scenario, have been reduced by the greatest percentage, which is not a reflection on perceived risk, but rather a display of the robustness of the benefit category. There are two trends in the container traffic which are clear. Over the last decade, container traffic through the Columbia has doubled. While this was happening, there has also been a consistent trend toward the use of larger container vessels on the West Coast. In light of these trends, the Port of Portland has long-term plans to expand container capacity, and plans to invest more than $300 million in developing new container terminals. The outlook for growth in Columbia container traffic is positive, and trends in new container vessels indicate that growth will also continue. Assuming these trends continue, it is highly unlikely that container benefits have been overestimated by 65 percent.

After looking closely at each of the benefit categories, it is apparent that there is no breakeven analysis that will represent a remotely probable scenario. Each benefit category is strong, and in combination, while it appears that each benefit category is unlikely to experience large declines, it is even more unlikely that all benefit categories will experience simultaneous long-term declines.

Table 118. Benefit Reduction Sensitivity

Commodity	Original Benefits	Percent Reduction of Benefits	Sensitivity Benefits
Corn	5,574,000	50	2,787,000
Wheat	8,414,000	75	6,311,000
Barley	1,096,000	50	548,000
Containers - Mid Port	999,000	40	399,000
Containers - Last Port	21,137,000	35	7,398,000
Total	37,220,000		$17,443,000

This breakeven analysis also addresses a concern regarding the possibility of eliminating or reducing the amount of shallow-draft traffic via drawdowns of the Snake River pools or the John Day pool which would primarily impact grain exports from Idaho, Washington, and Oregon.

In general, the majority (approximately 60 percent) of the wheat and barley exported from the Columbia arrives at the export terminal by rail. Corn is almost exclusively moved by rail, and only 10 percent of container traffic travels by barge. As can be seen above, all of this tonnage can be eliminated from the benefit estimate without significantly impacting the selected plan.